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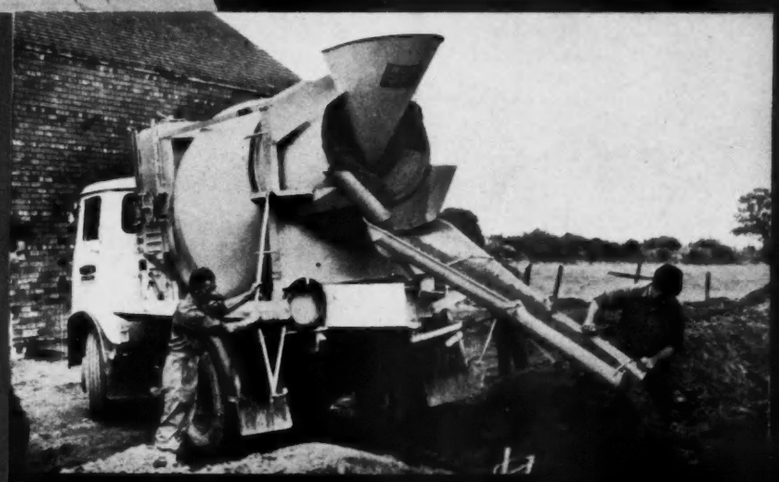

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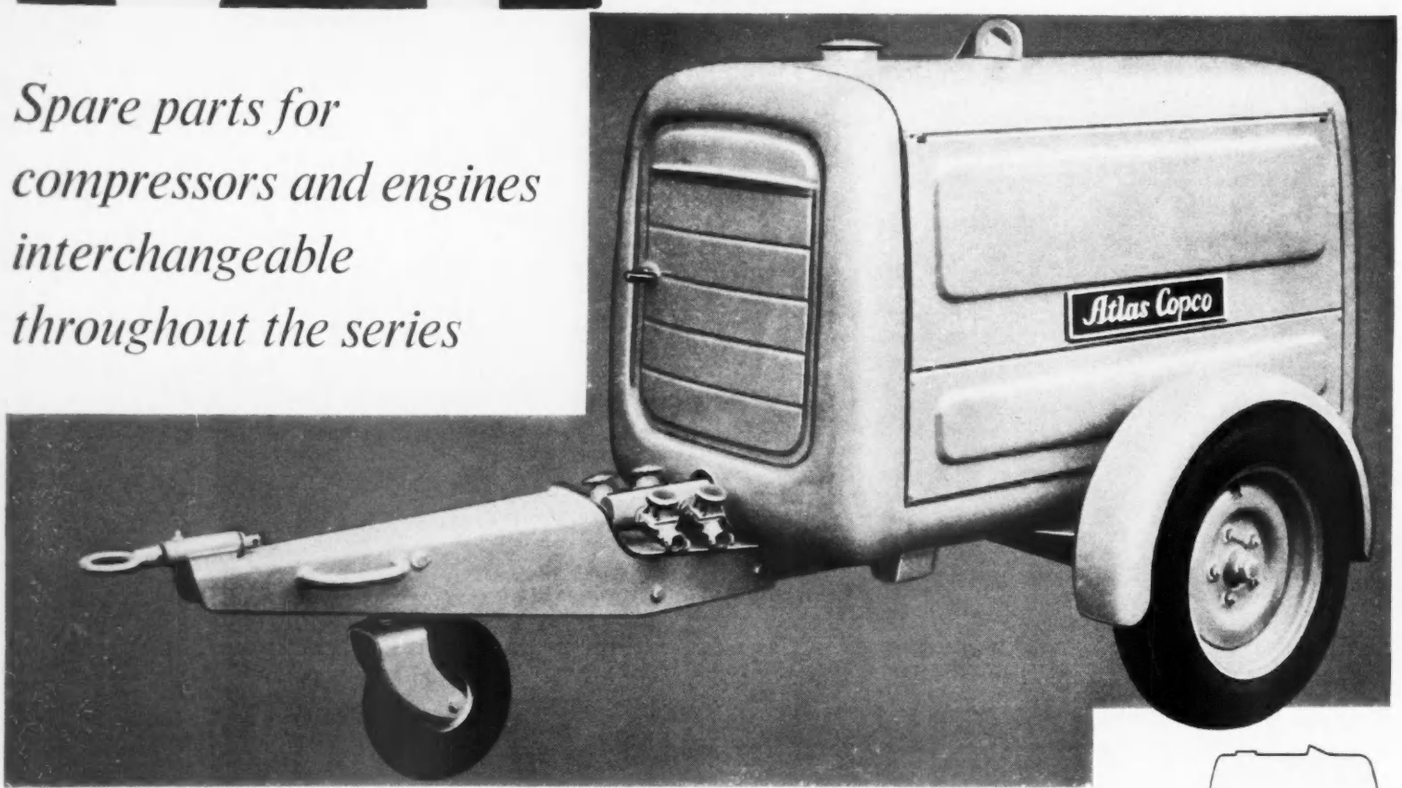

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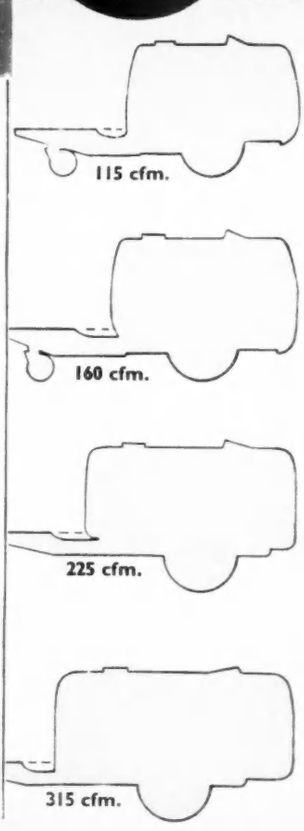

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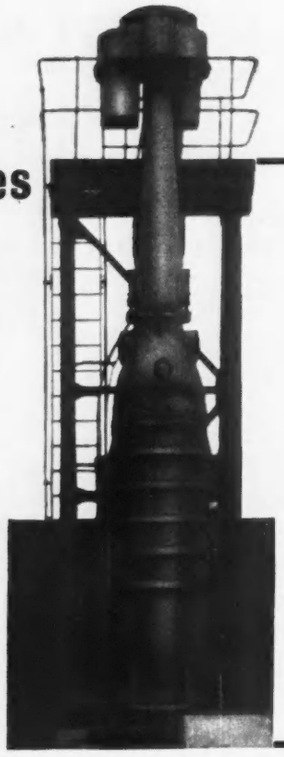

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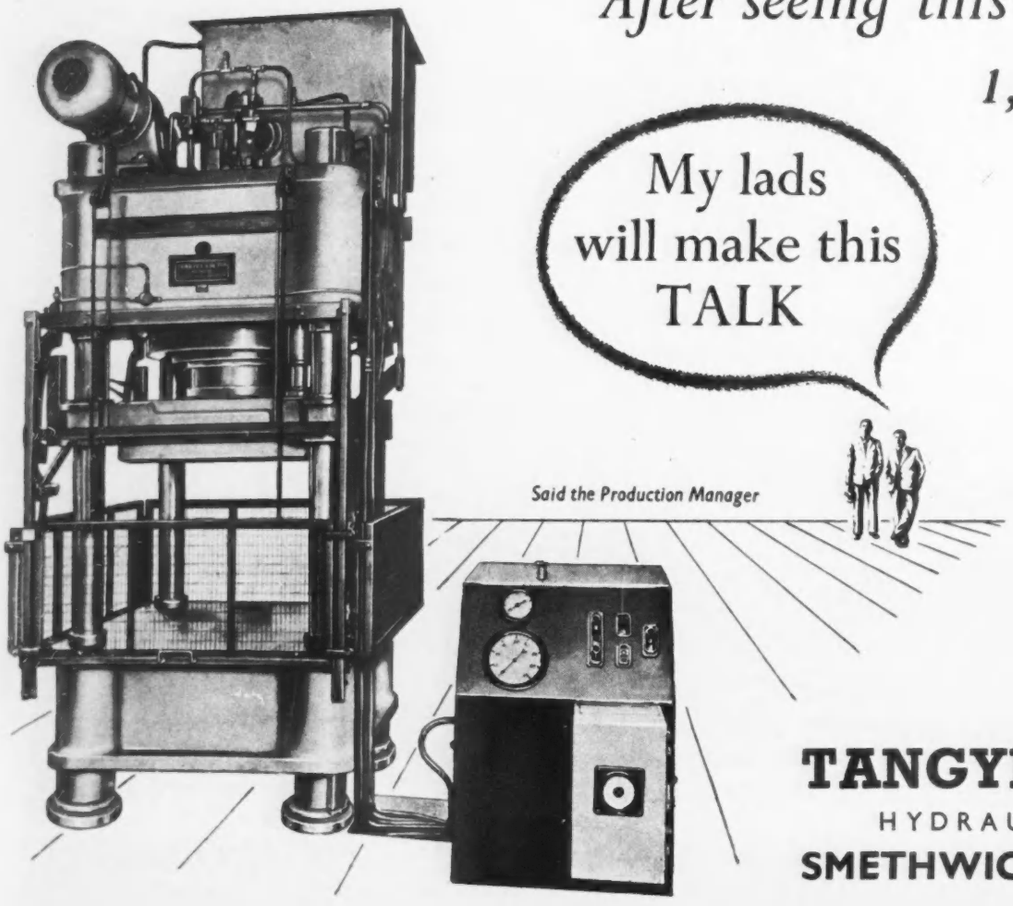

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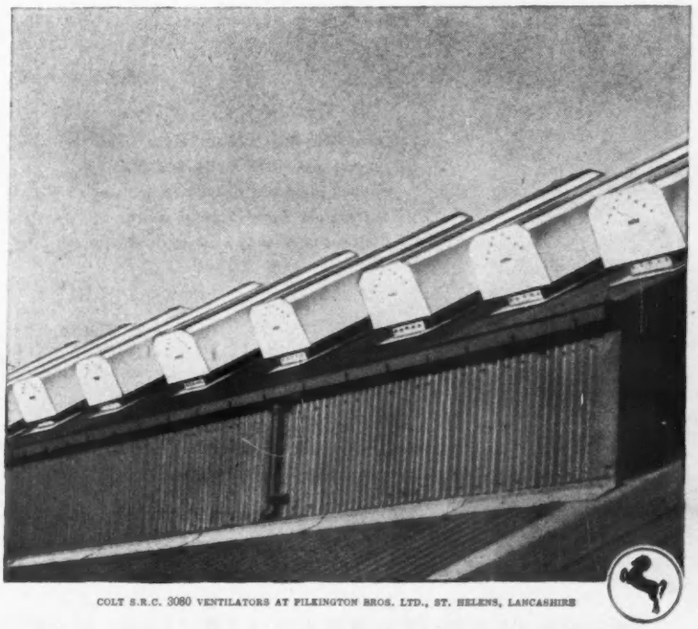

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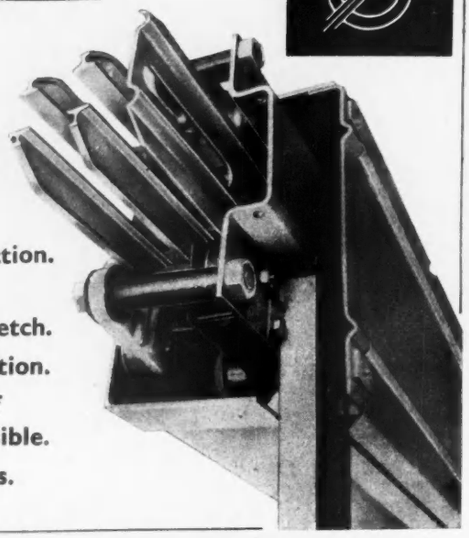

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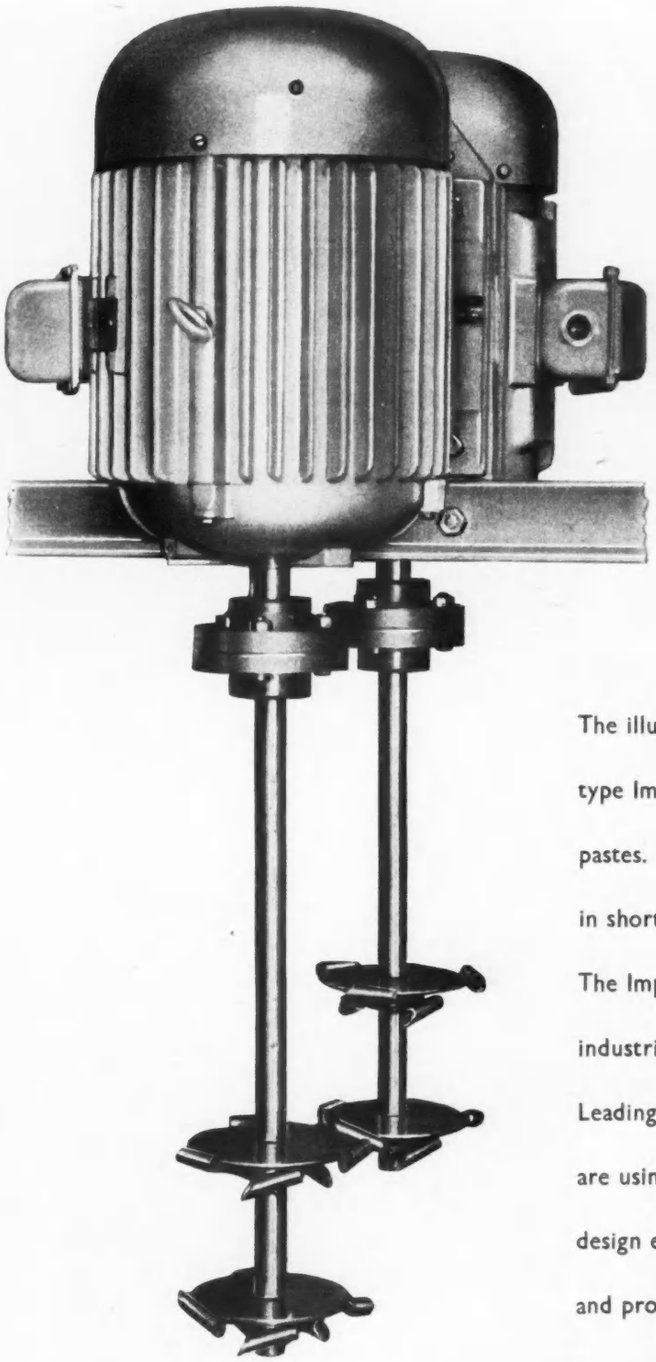

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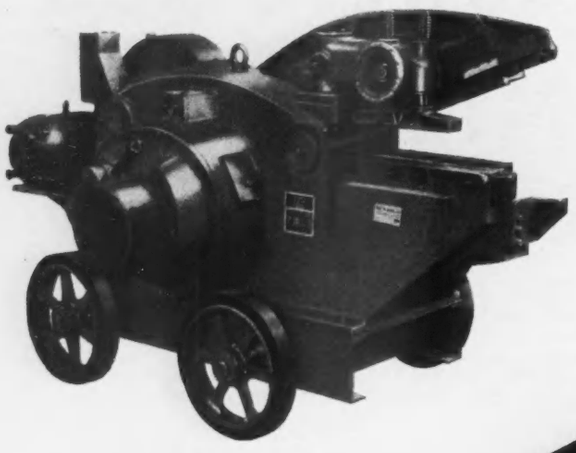

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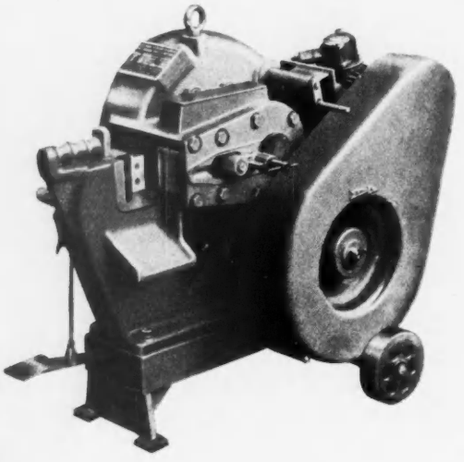

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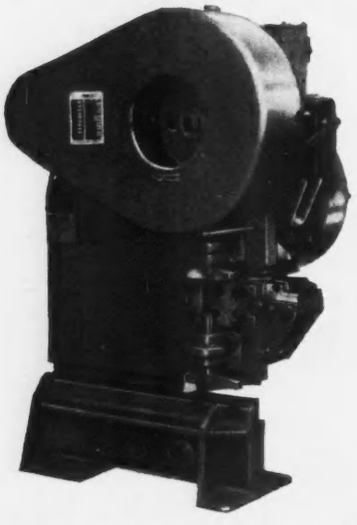

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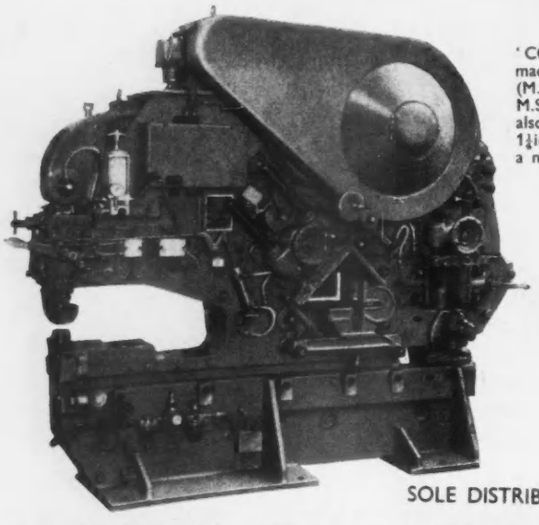

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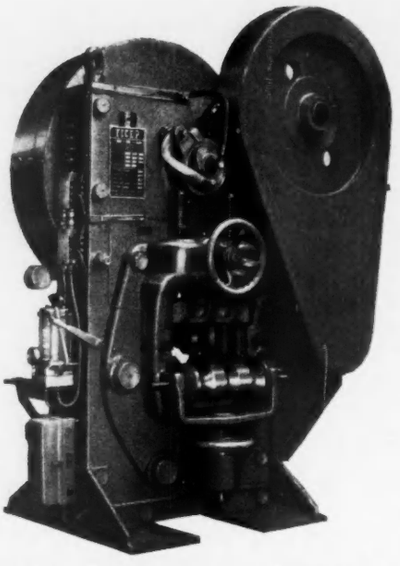

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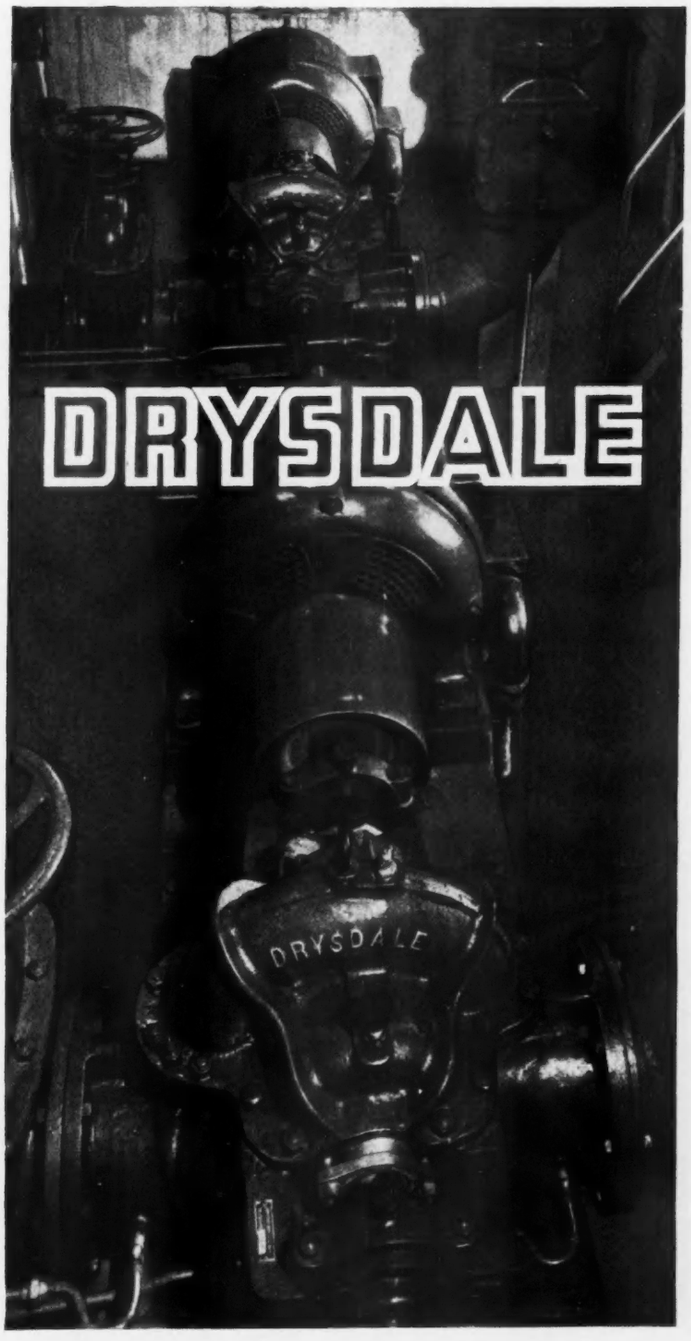

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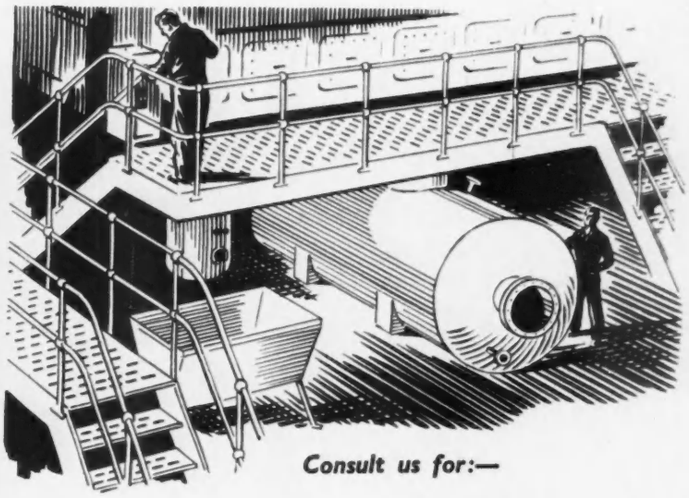

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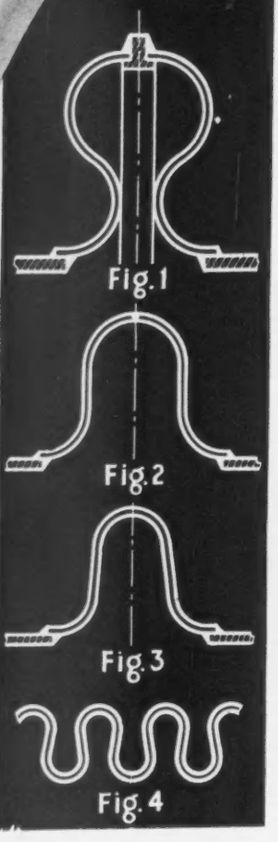

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Fig. 2 An alternative bellows profile particularly suitable for transverse movement. The height of the bellows is varied to suit individual pressures and working conditions.

Fig. 3 A bellows profile which may be formed by deep pressing. This type of expansion fitting is built up in three or more sections with longitudinal welds.

Fig. 4 One of the profiles available for the Aiton "A" type expansion fitting. This unit is made by a special process which obviates the need for circumferential welding at the crown of, and between, convolutions.

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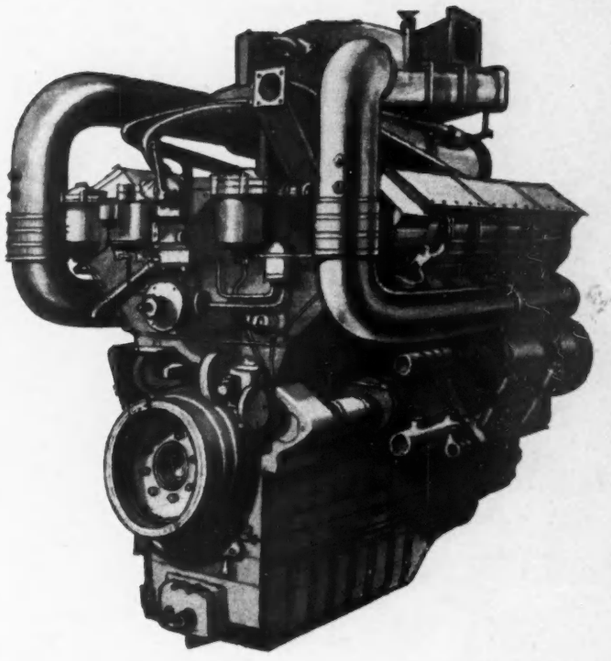

Typical of the MD range of engines is this Type 650 12 cylinder supercharged model with cylinders arranged in 'V' formation.

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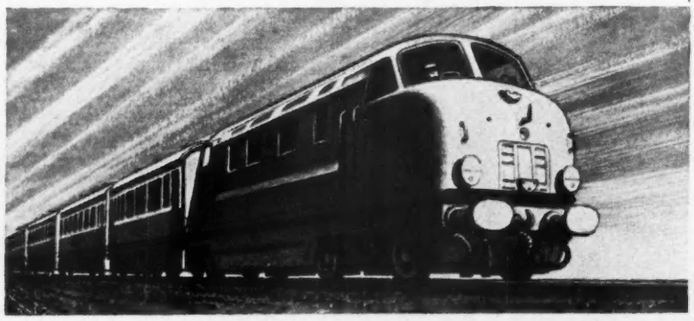

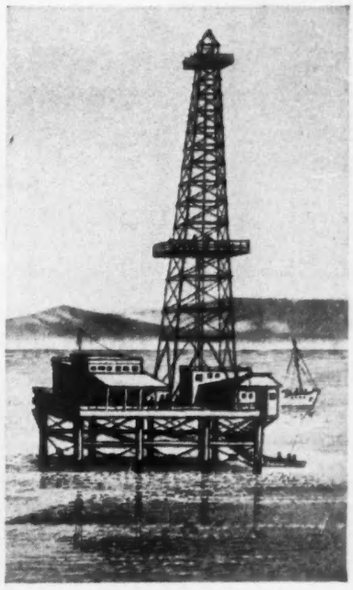

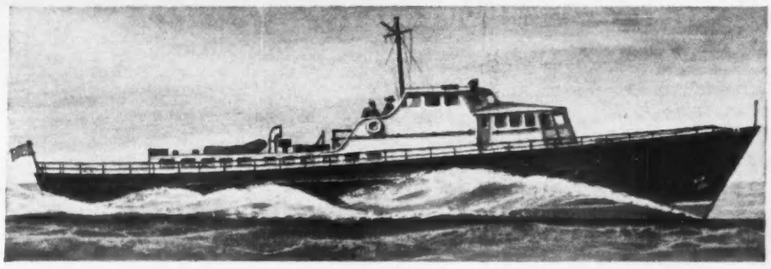

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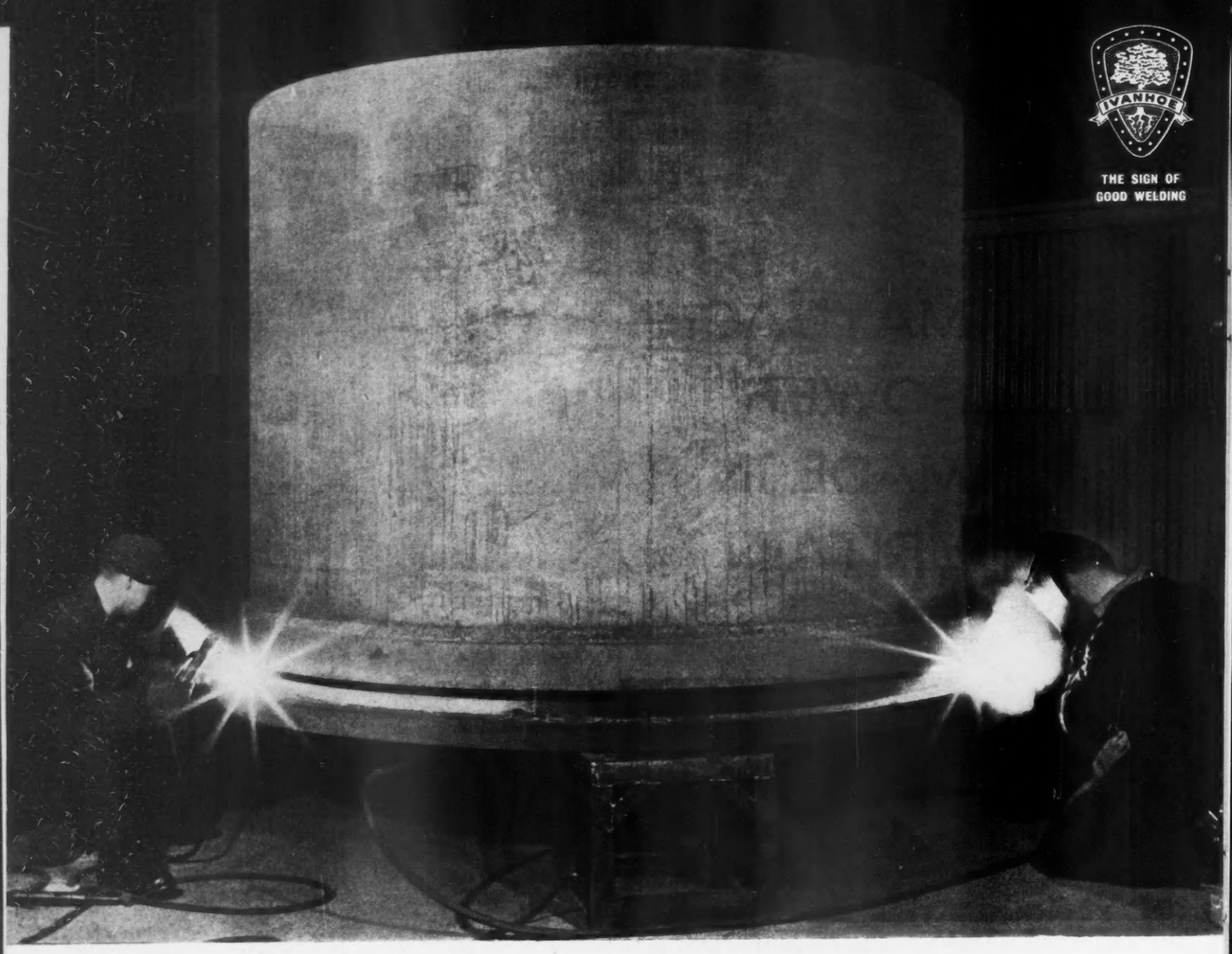

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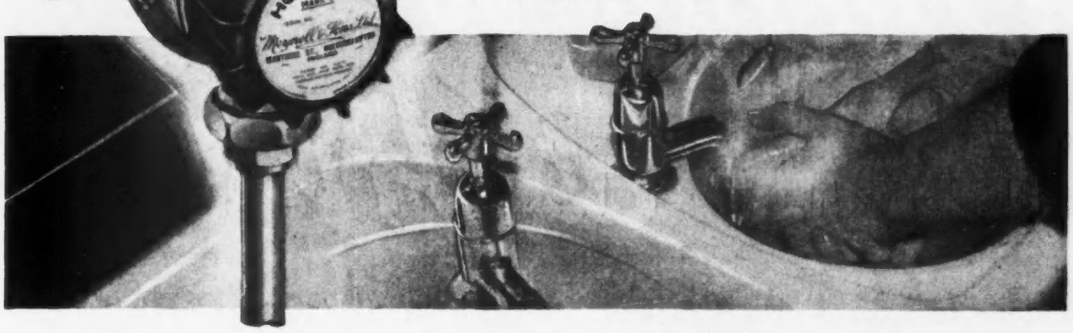

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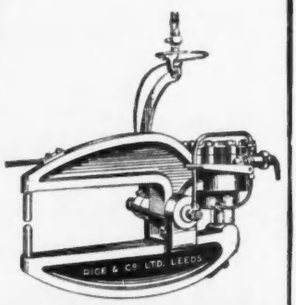

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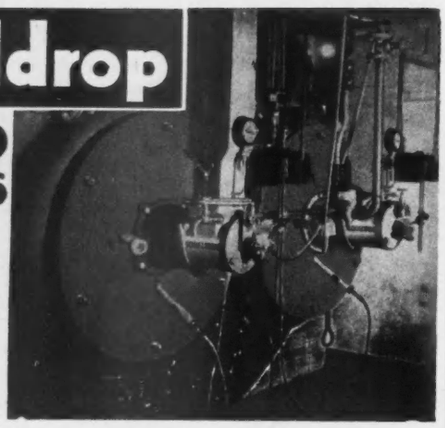

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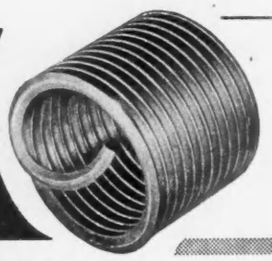

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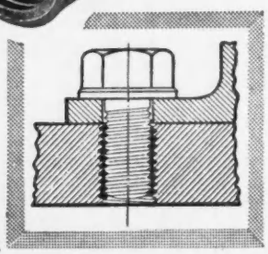

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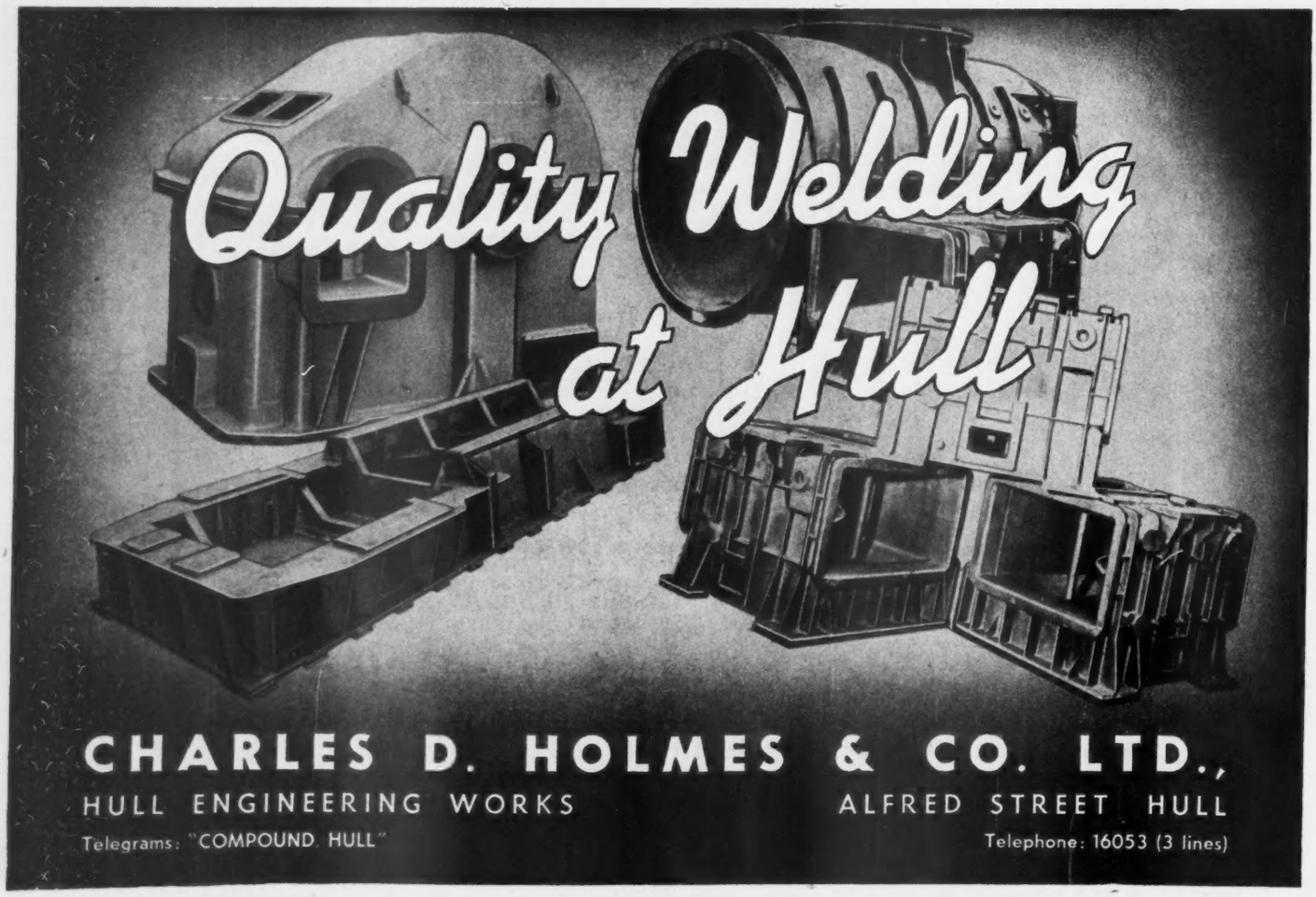

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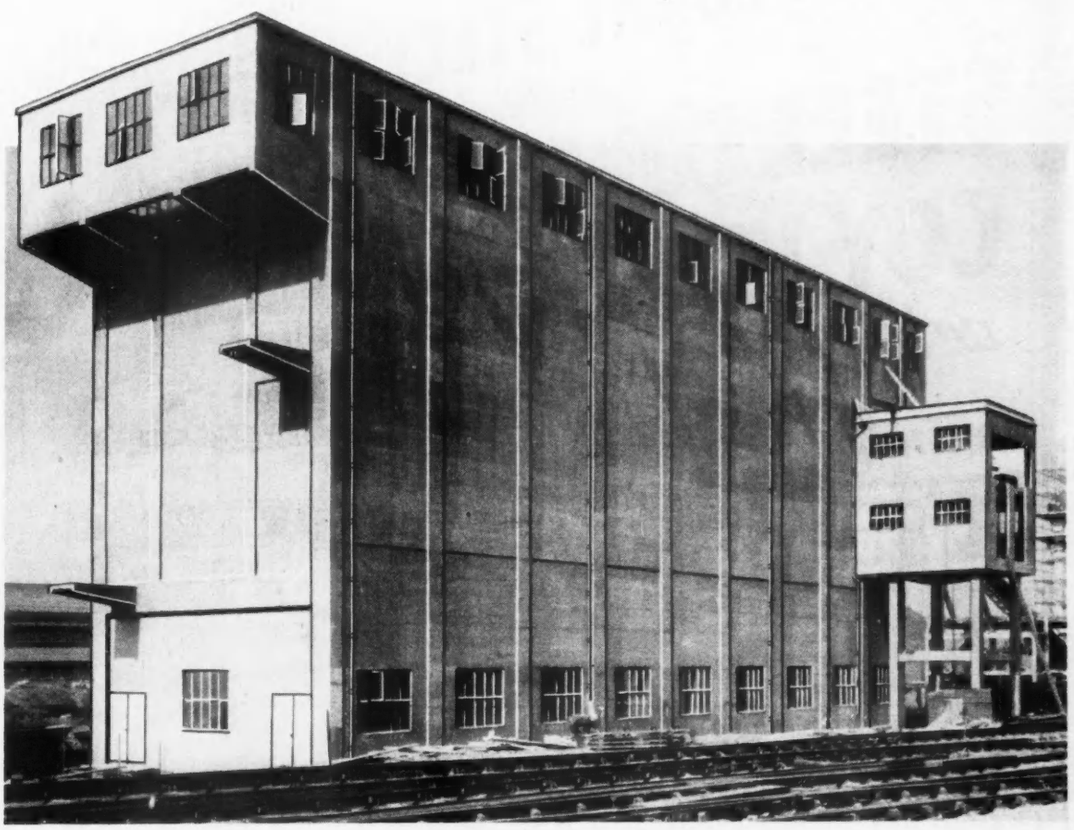

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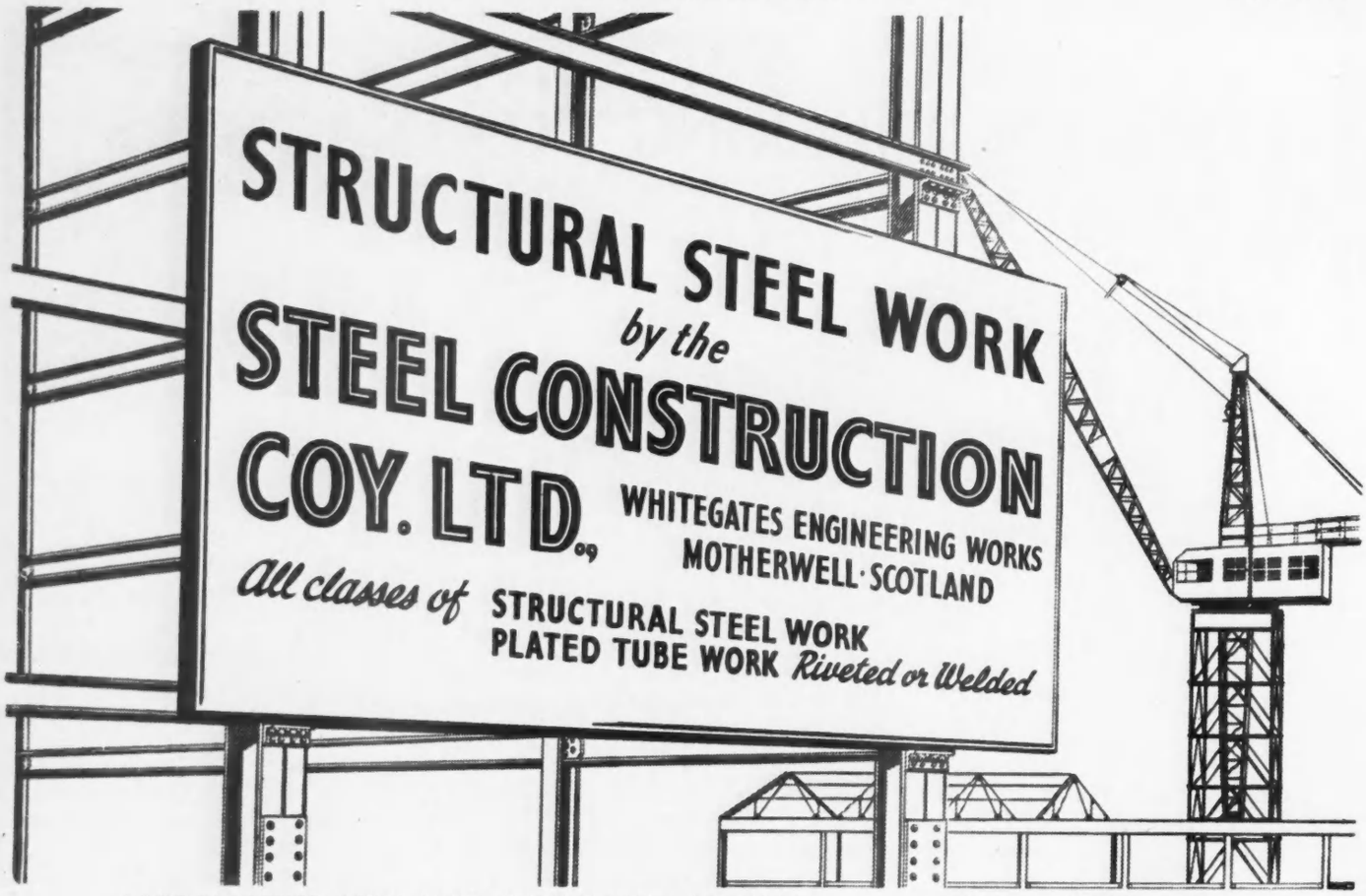

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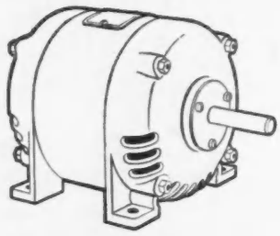

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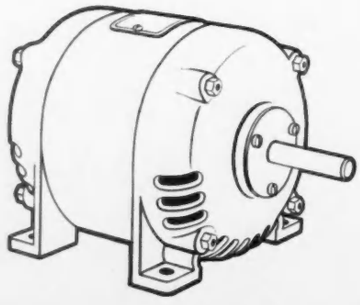

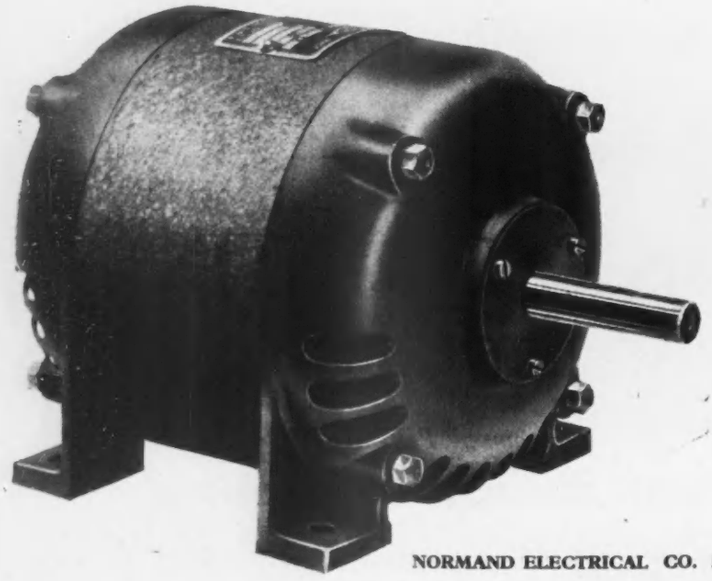

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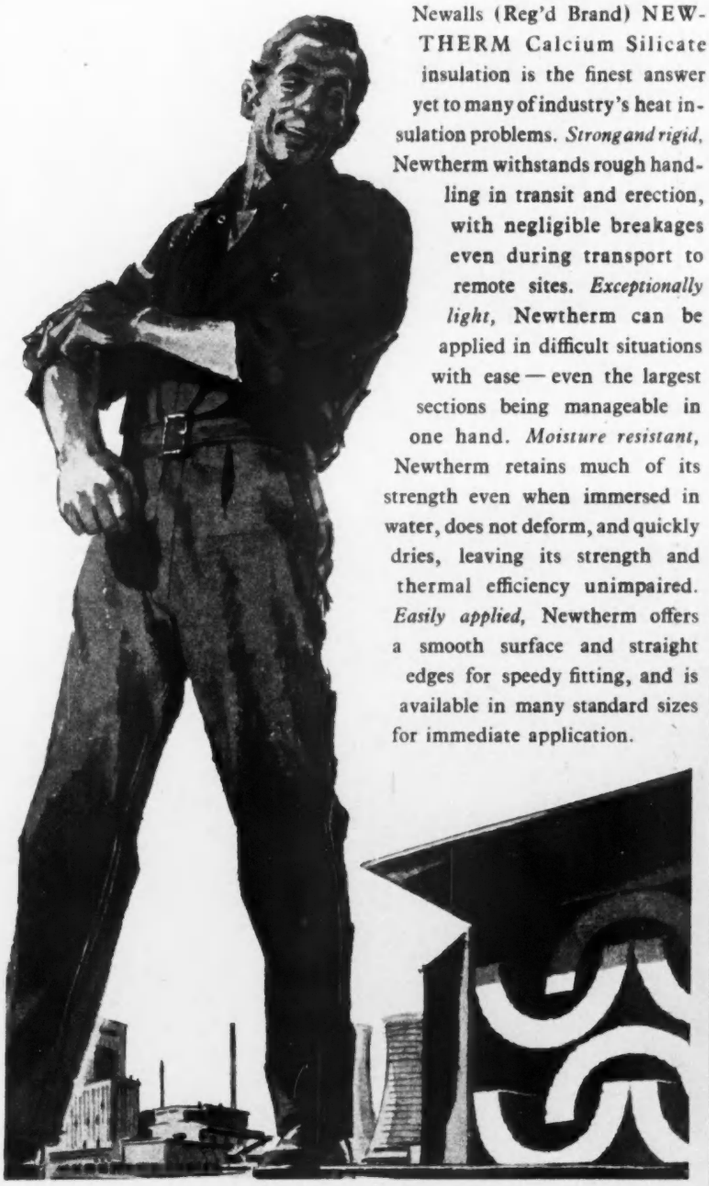

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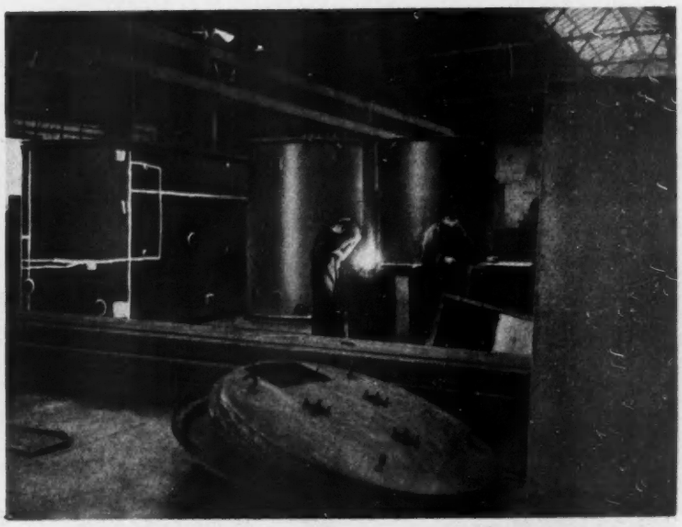

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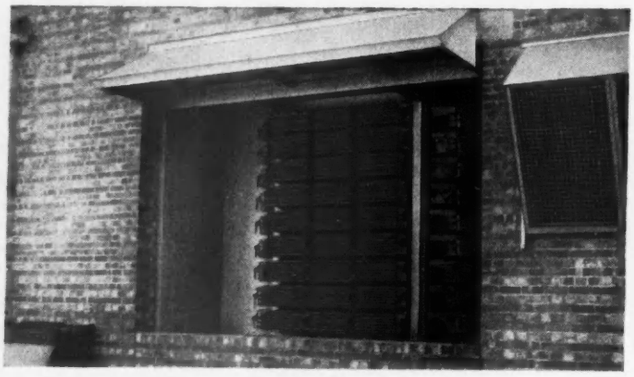
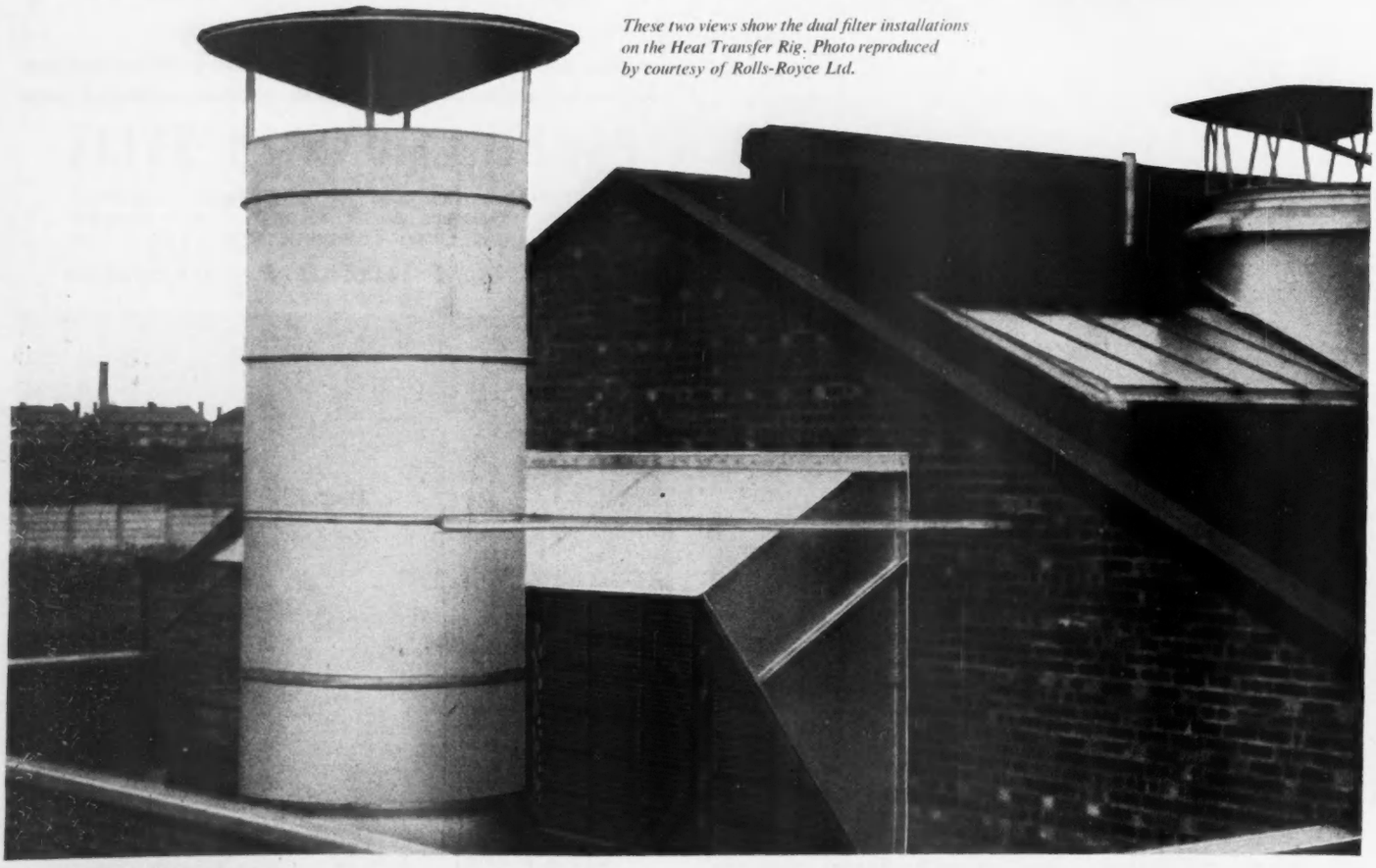


*** When specifying your filtration requirements, we strongly recommend that you request test information against B.S.S. 2831.**

These two views show the dual filter installations on the Heat Transfer Rig. Photo reproduced by courtesy of Rolls-Royce Ltd.



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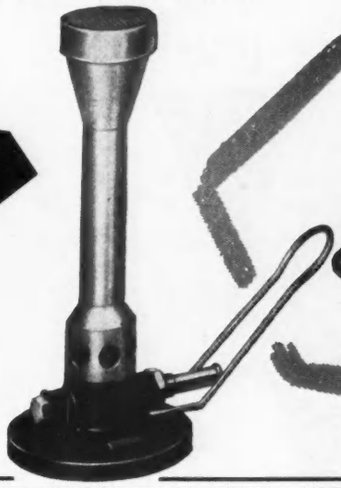

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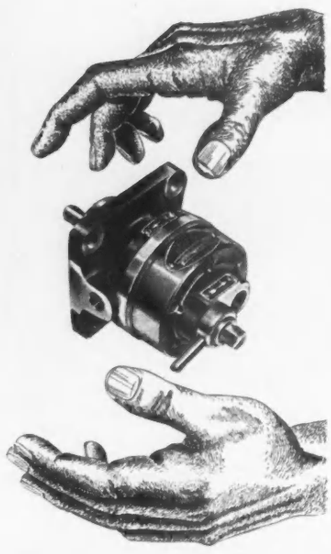

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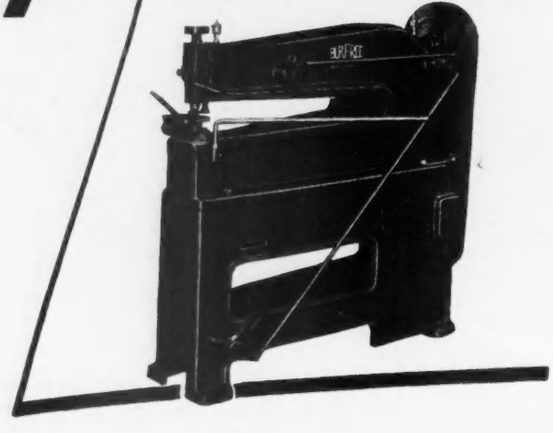

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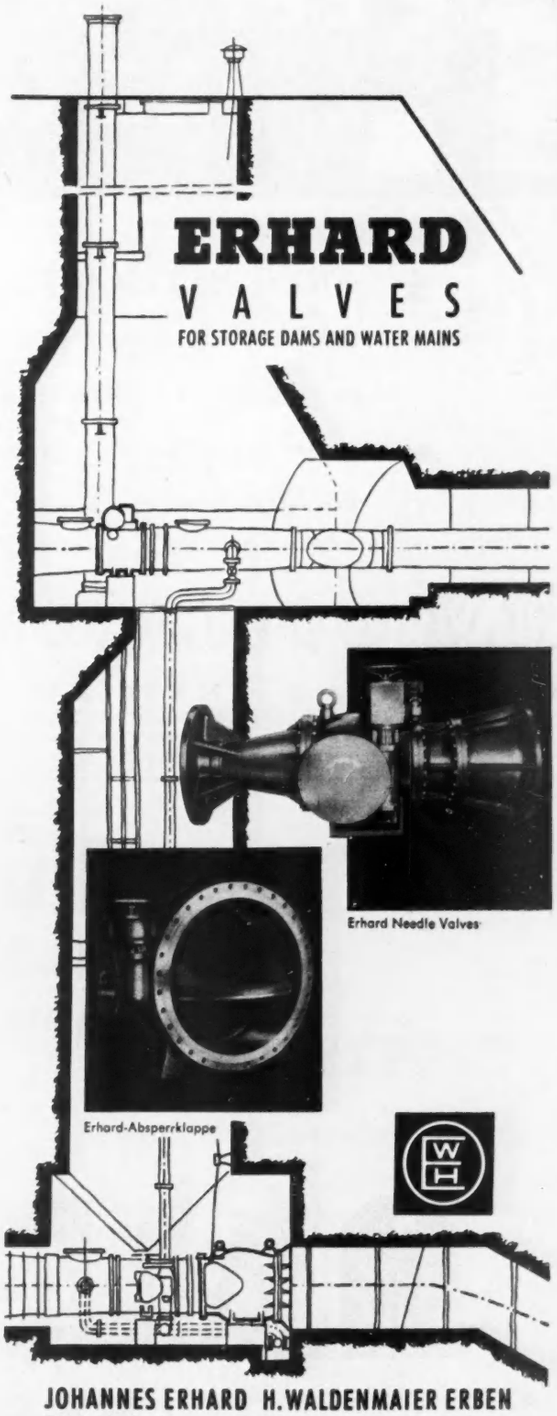

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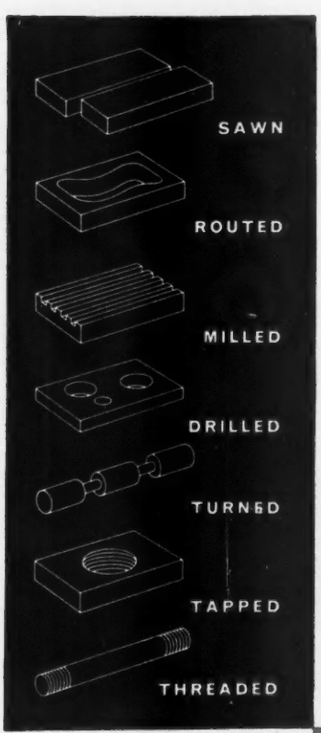

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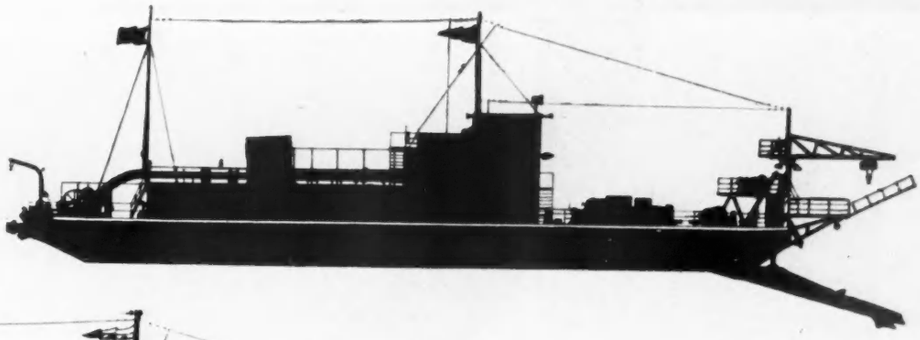

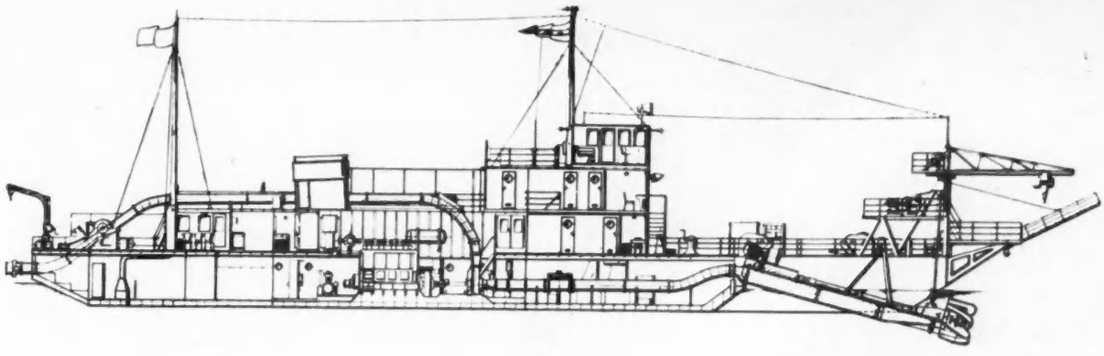

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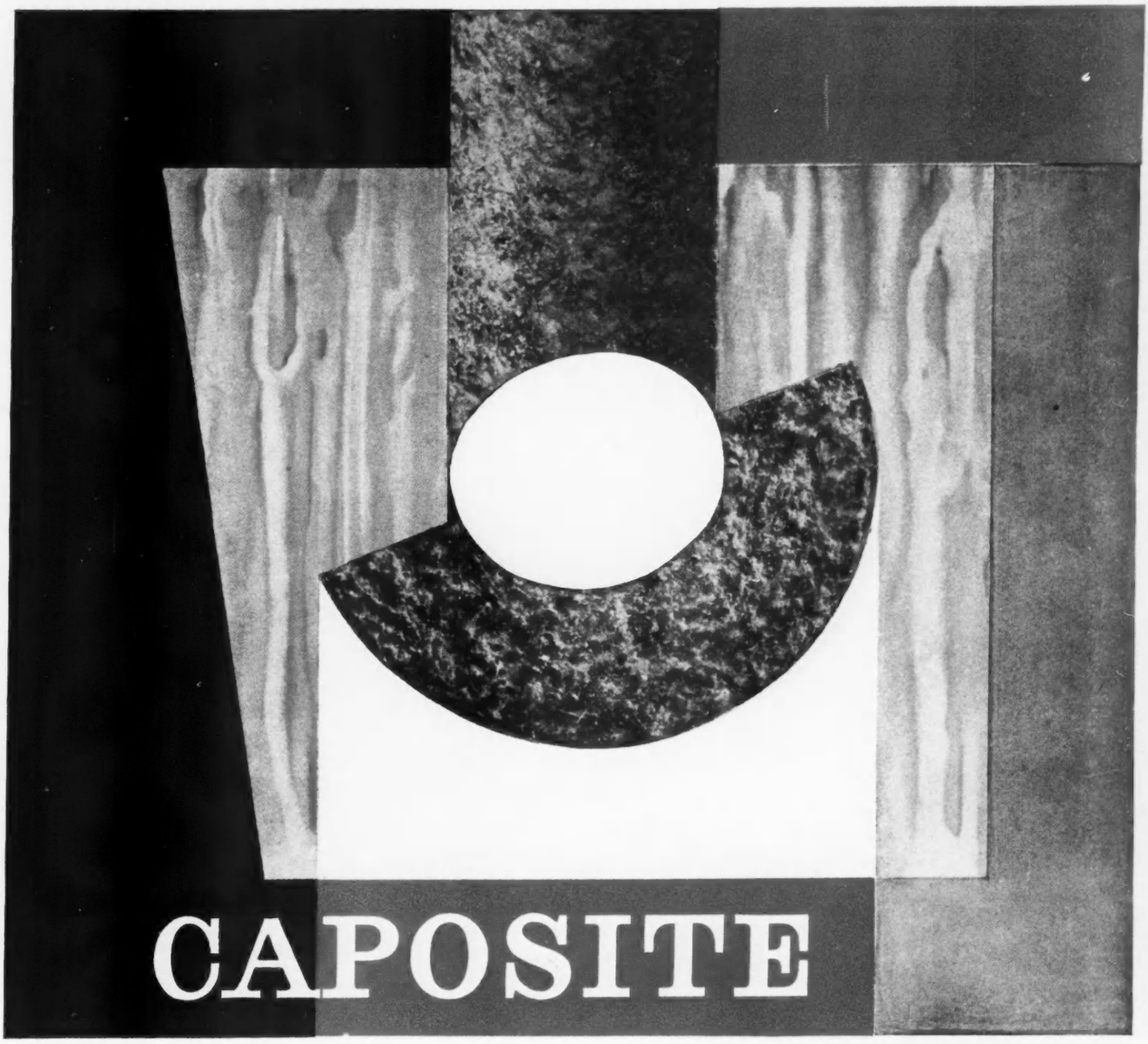

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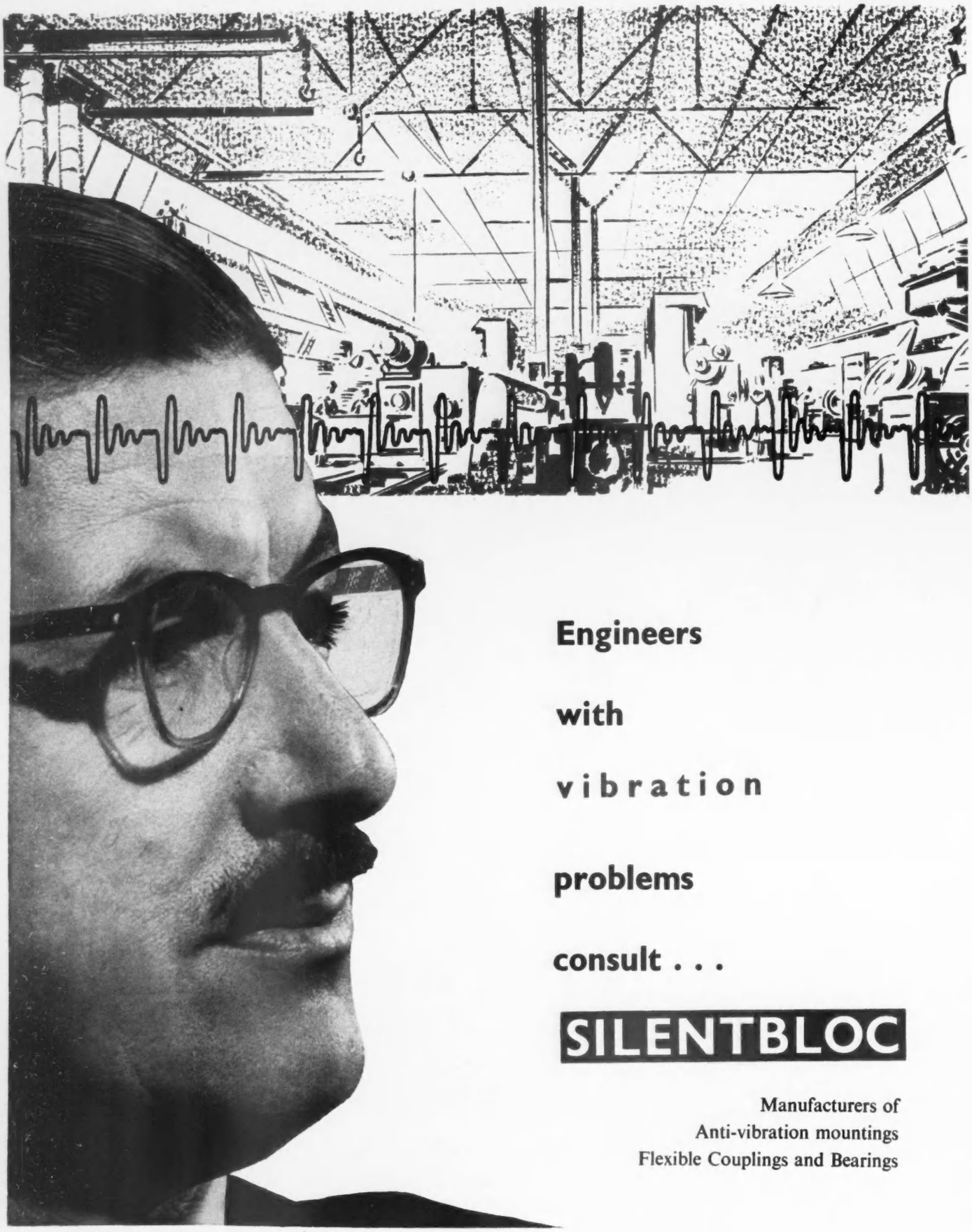

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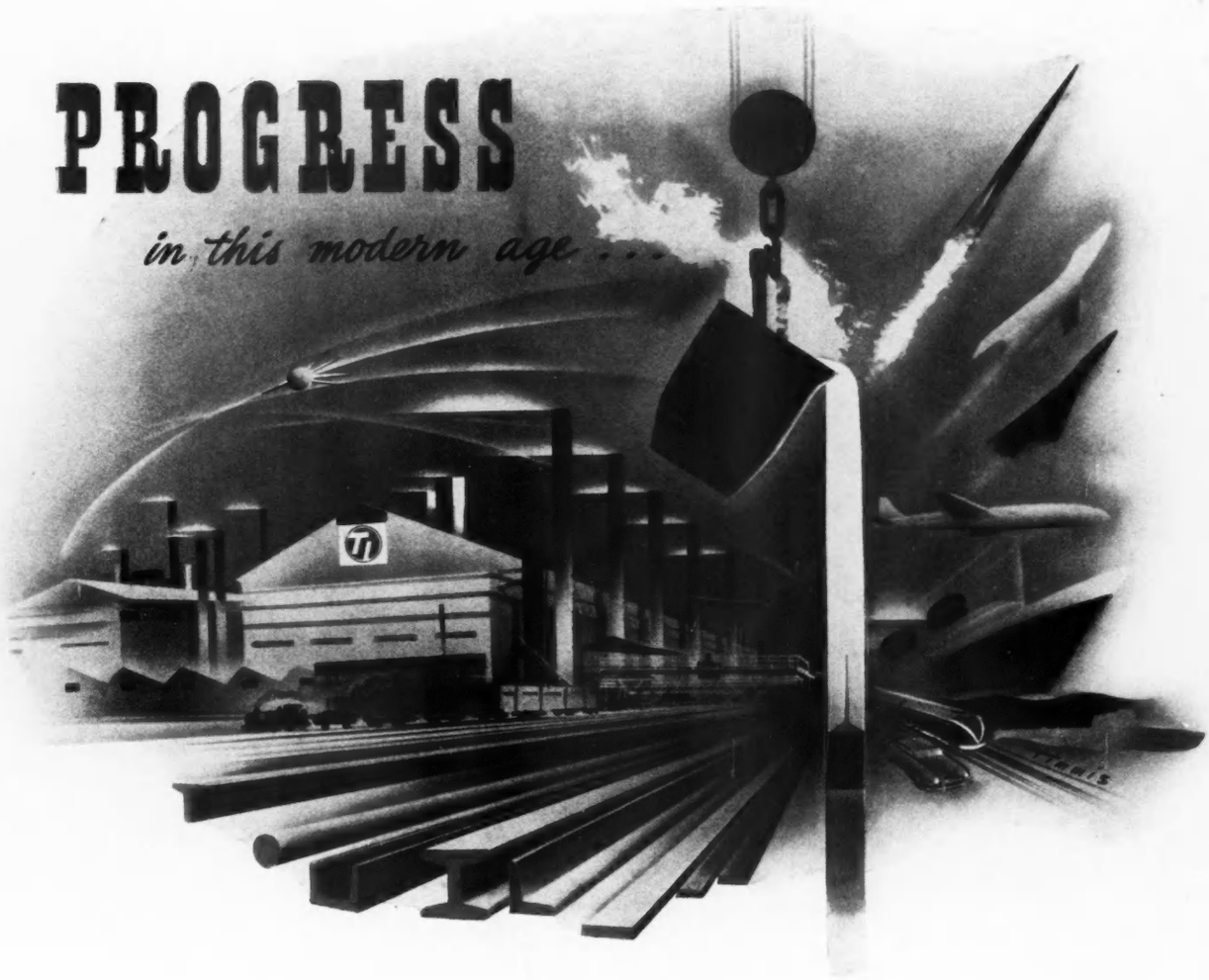

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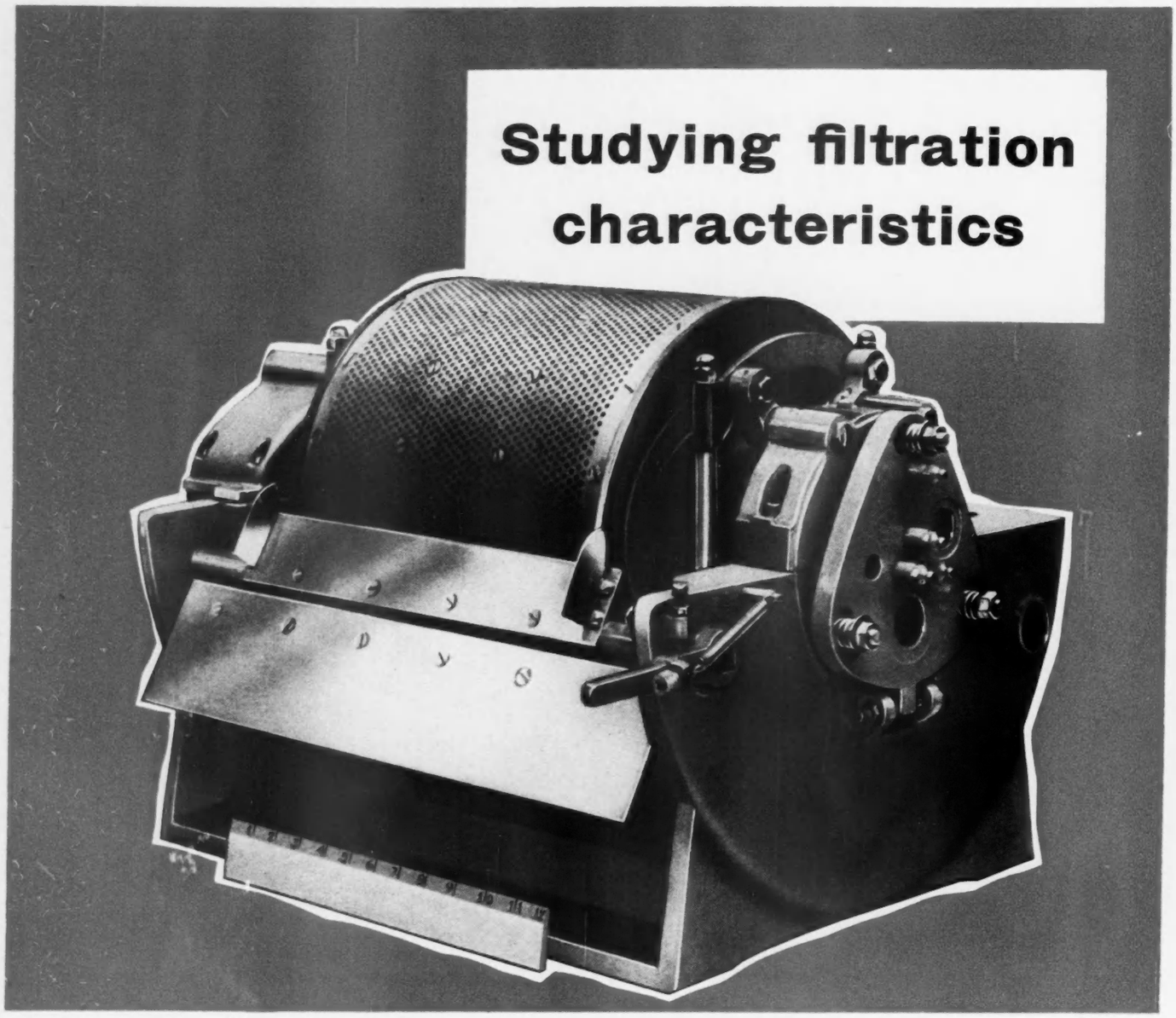

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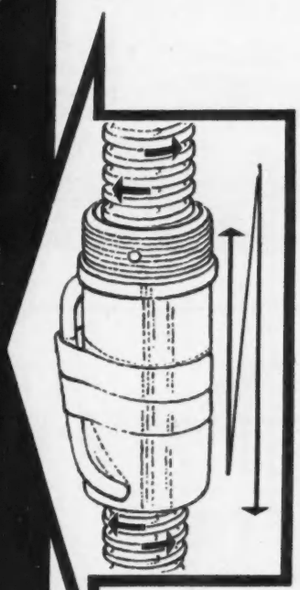

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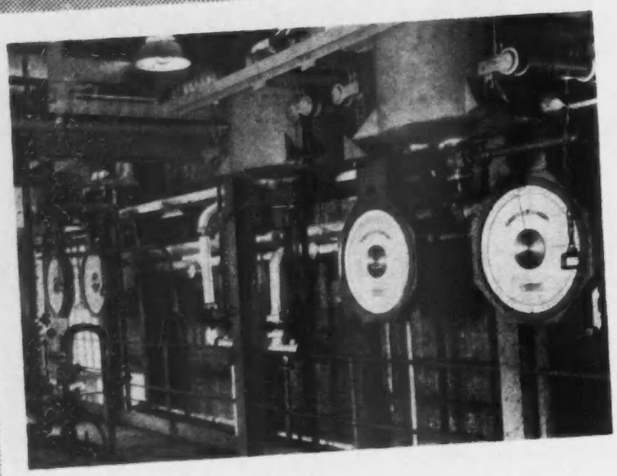

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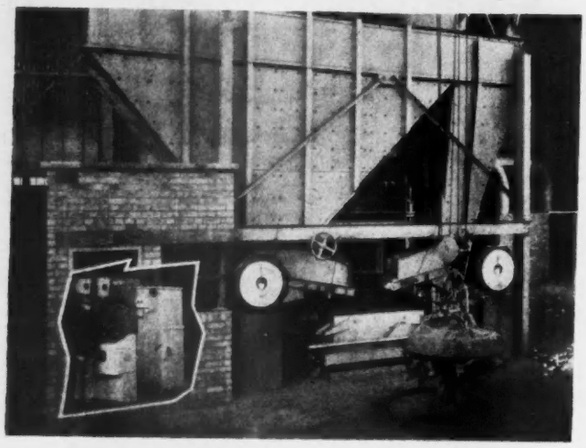

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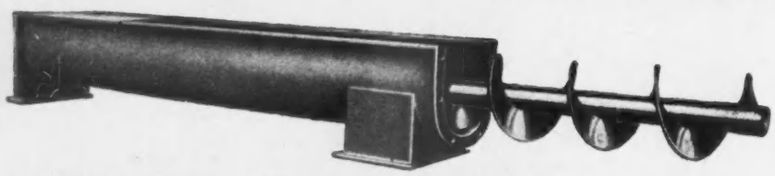

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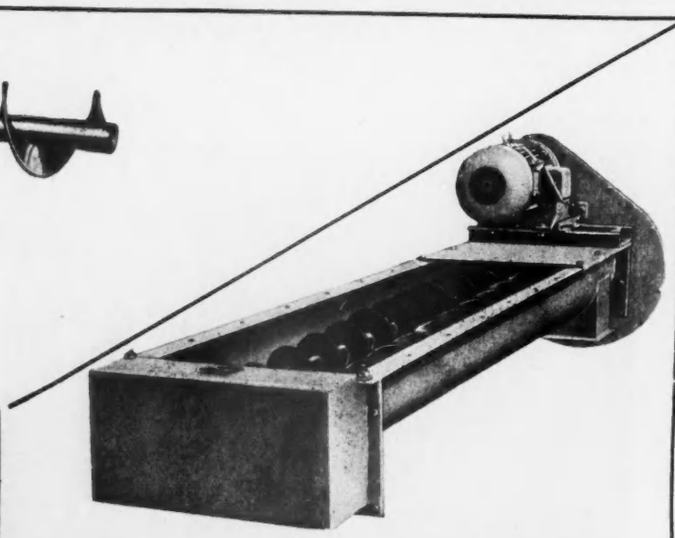

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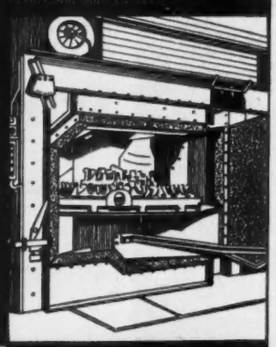

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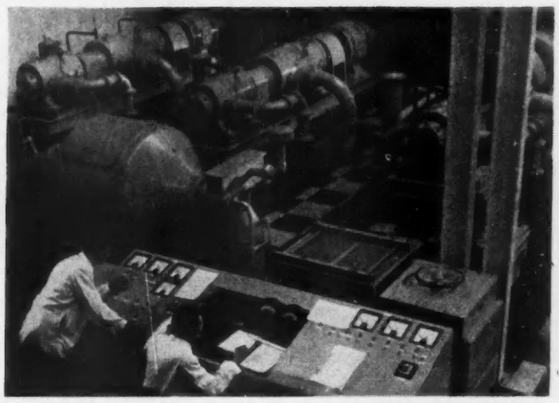

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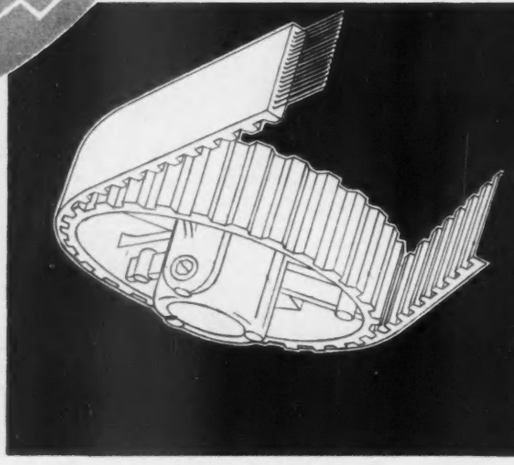

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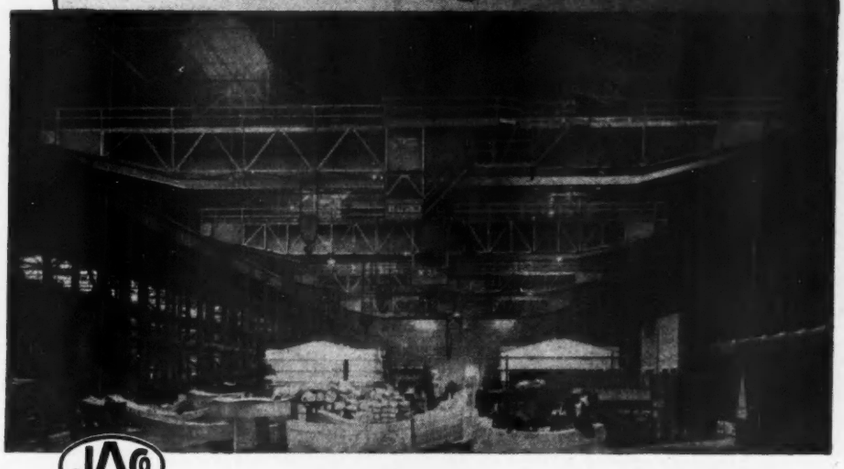

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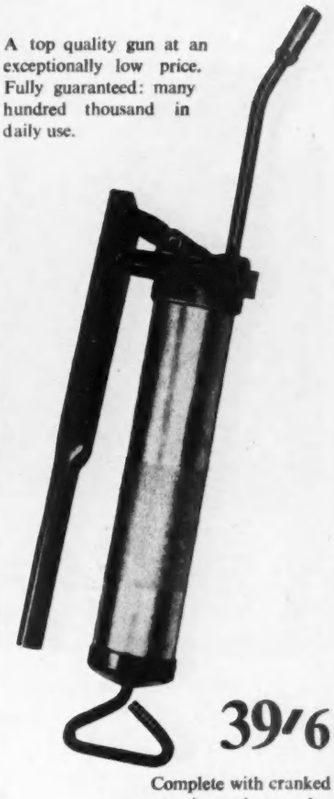

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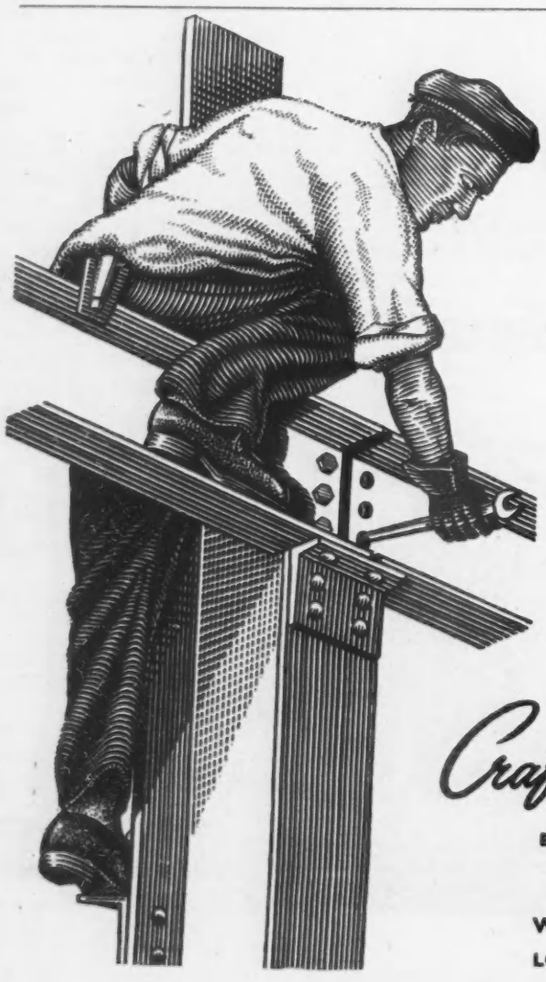

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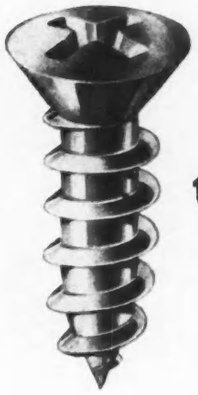
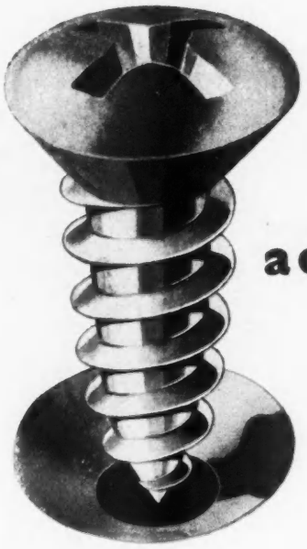


there is

a plain



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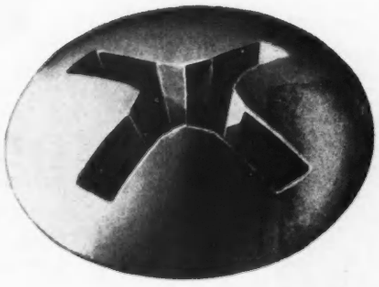

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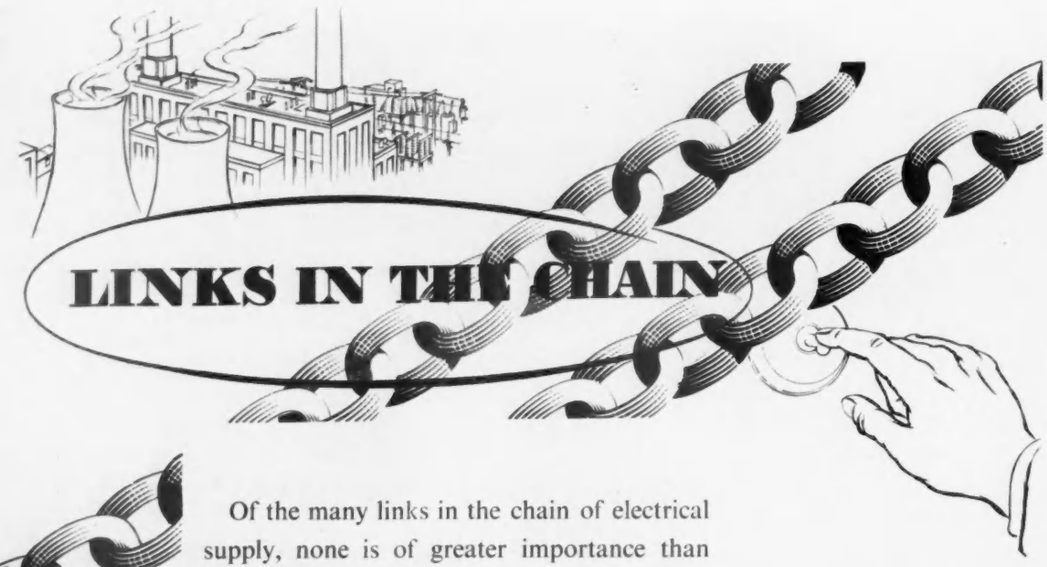

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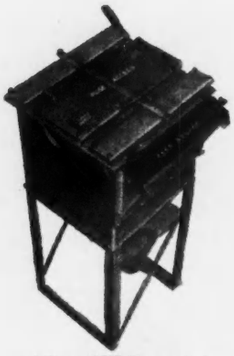
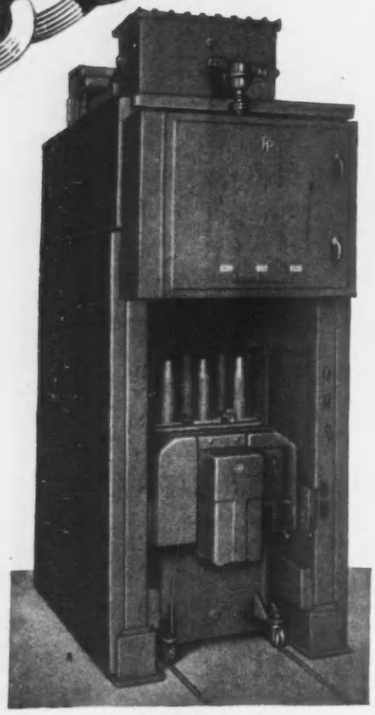


A Type OFS Fuse-switch



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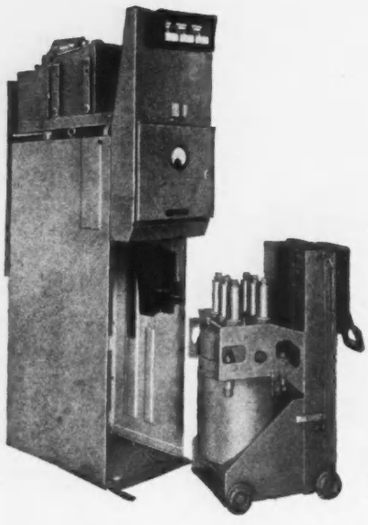

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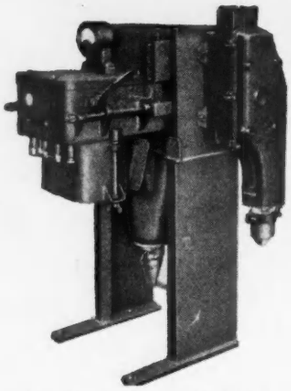

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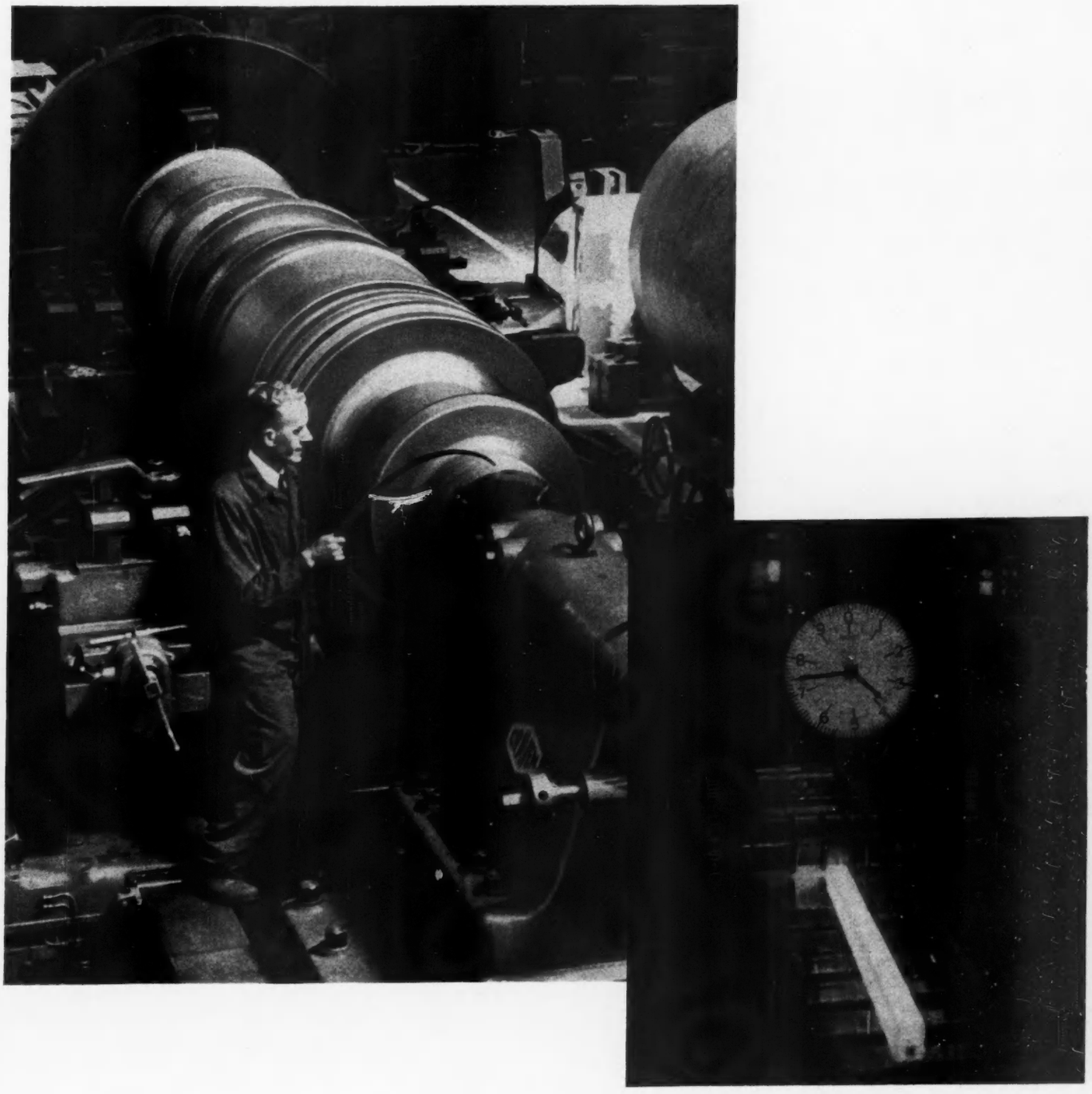

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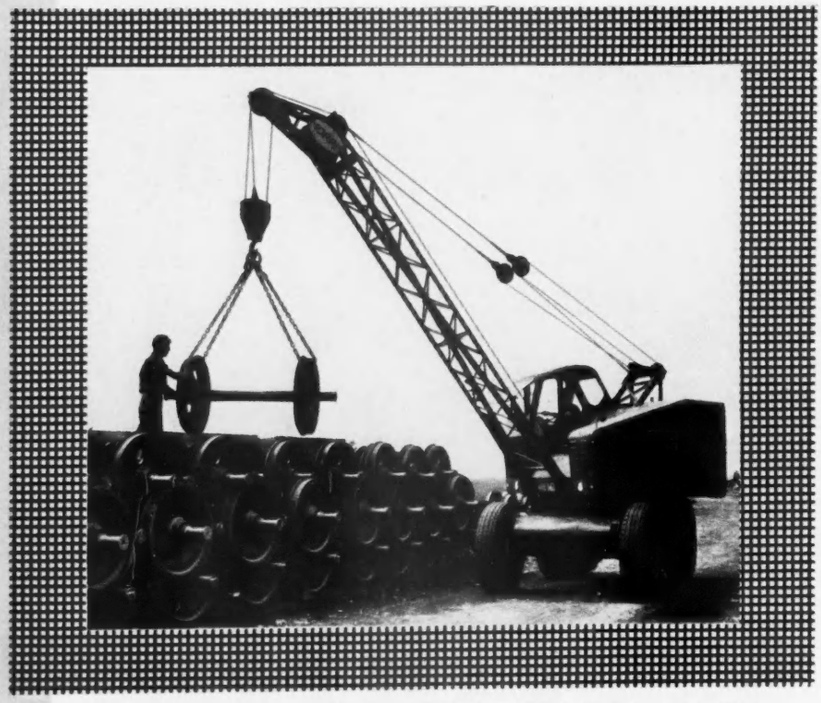

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With characteristics similar to 'A' and 'B' types but double the deflection, this series is especially suitable for machines in the lower speed range. Deflections up to 1" can be obtained by fitting two mountings, one above the other.

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Cushyfoot mountings can be supplied with frictional locating pads which obviate bolting down.

Full particulars of Cushyfoot mountings on application.

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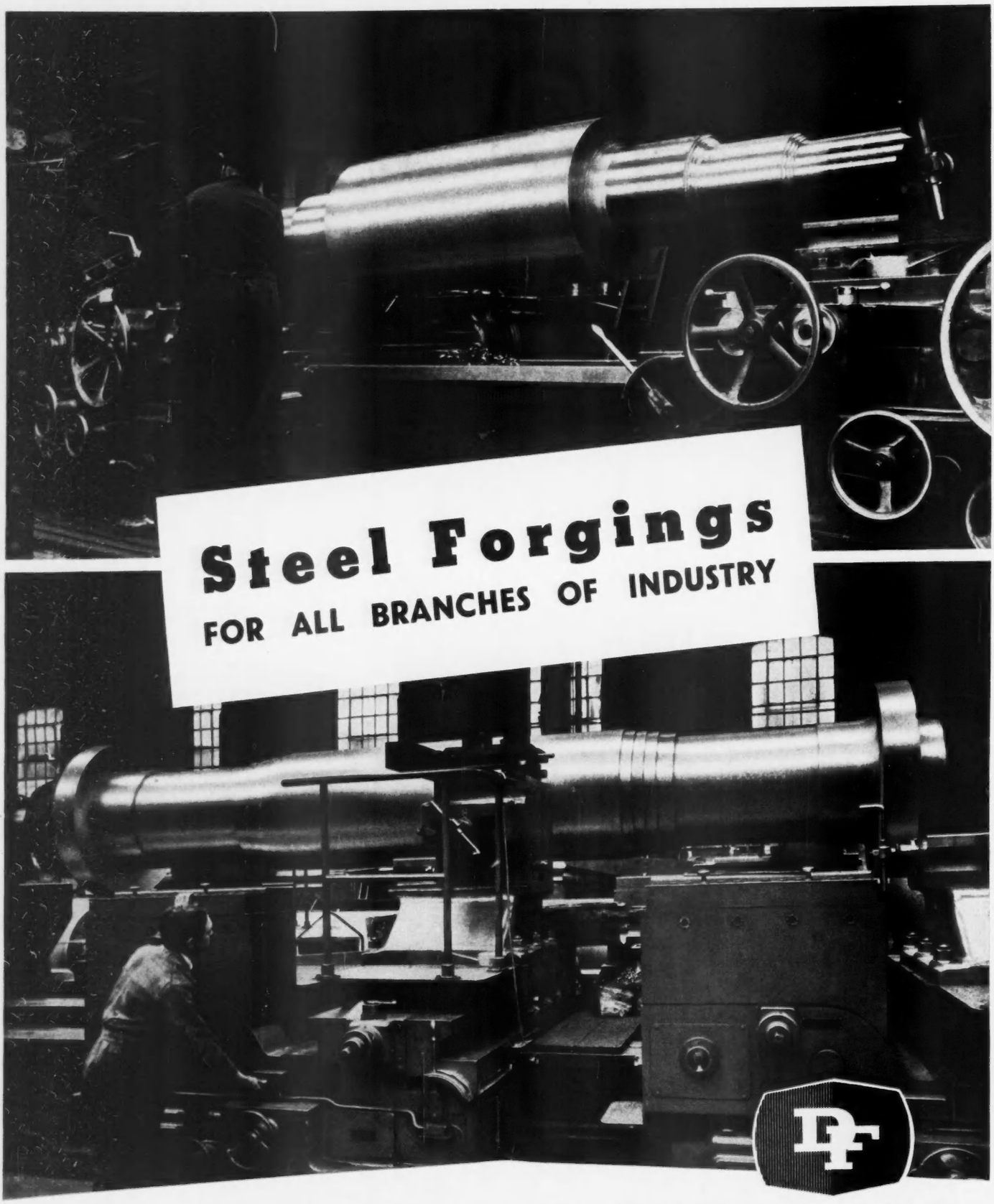
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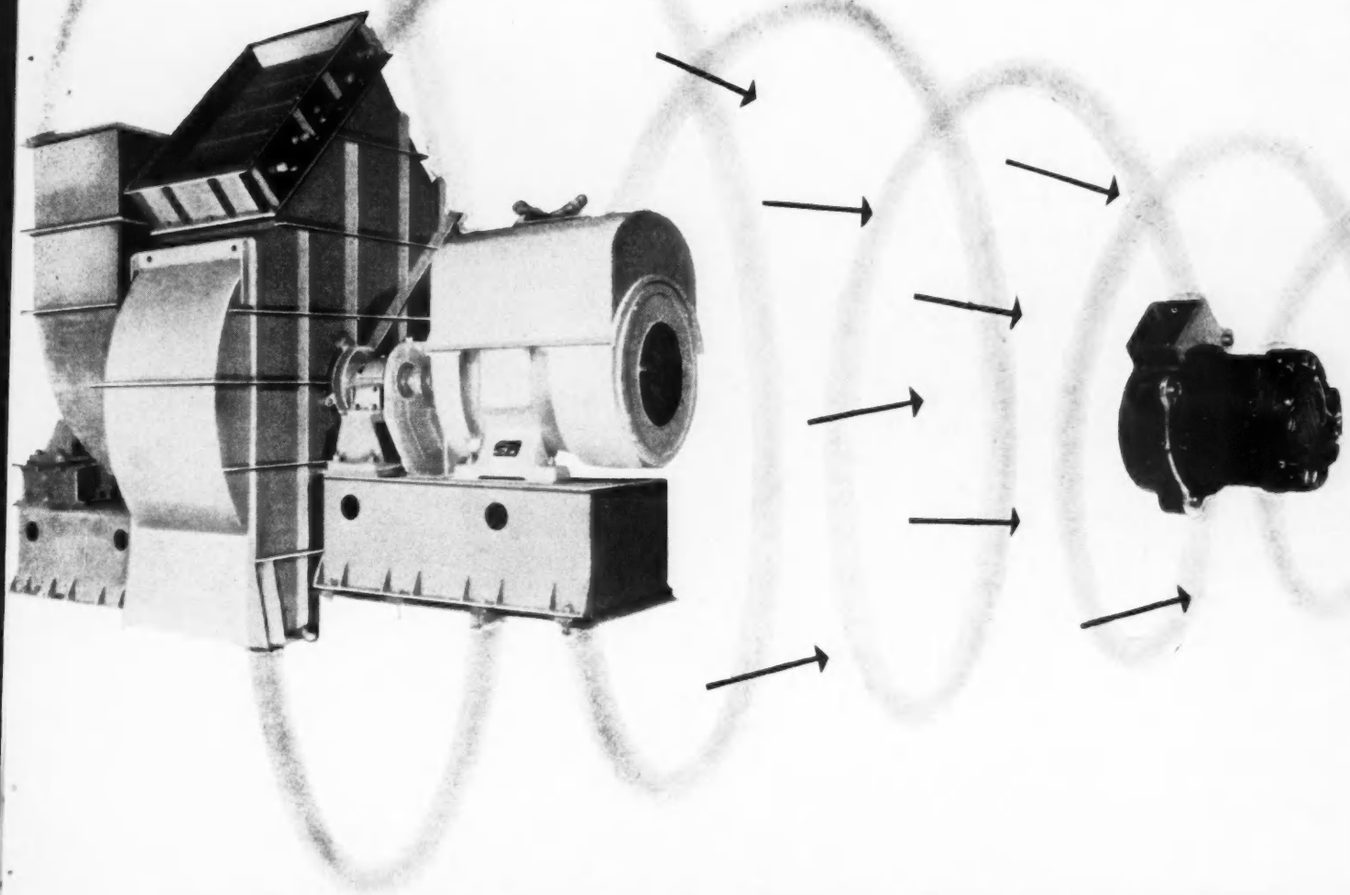

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'Fluon' in valve for use on high pressure superheated steam

The gland on the valve illustrated consists of 'Fluon' p.t.f.e. chevrons held in correct adjustment by a cylindrical gland pressure sleeve by means of shims .005 in. thick. The 'Alcon' Type ACHW.15 hand reset valve has a cast steel body for use on high pressure superheated steam.

A great feature of 'Fluon' is its outstanding working temperature range from +250°C. down to liquid nitrogen temperatures. It is virtually immune to all forms of chemical attack. 'Fluon' is flexible and has excellent non-wetting and non-stick properties. It is, furthermore, an extremely tough and long lasting material.

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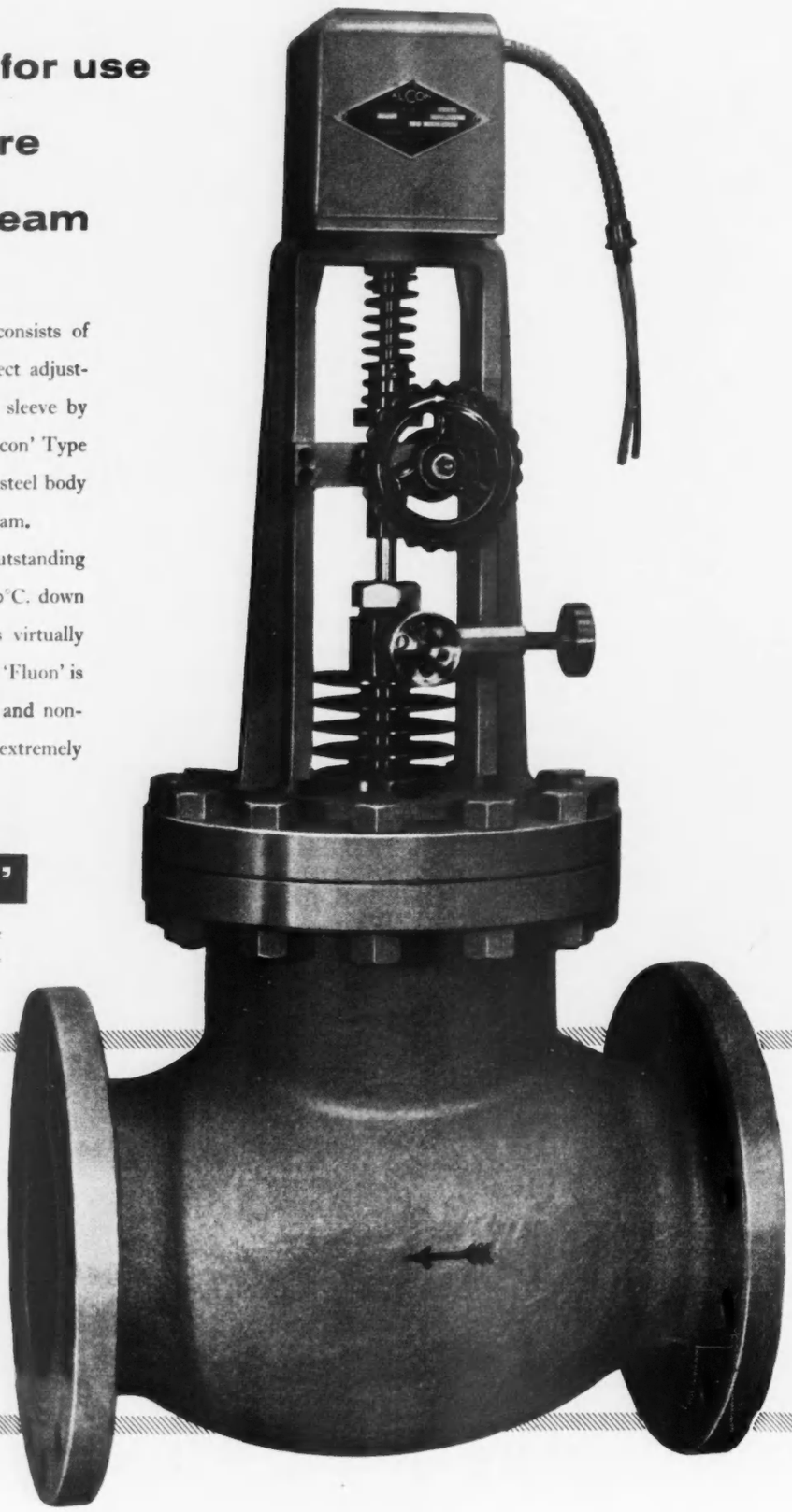
'Fluon' is the registered trade mark for the polytetrafluoroethylene manufactured by I.C.I.



The gland on this 'Alcon' Type ACHW.15 hand reset valve made by Alexander Controls Ltd. contains chevrons made from 'Fluon' p.t.f.e. by the Dunlop Rubber Co. Ltd. (General Rubber Goods Division) Cambridge Street, Manchester 1.

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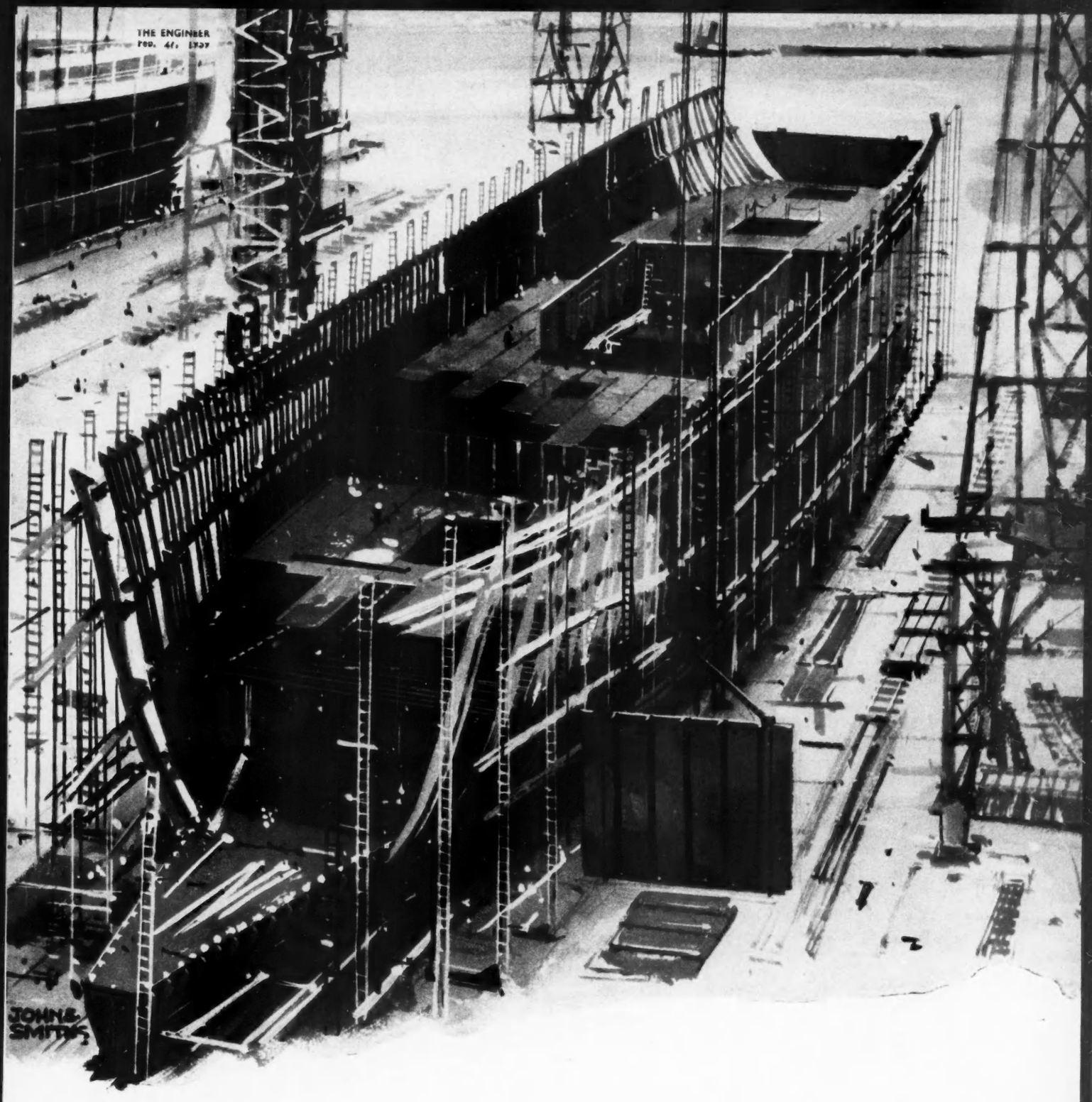

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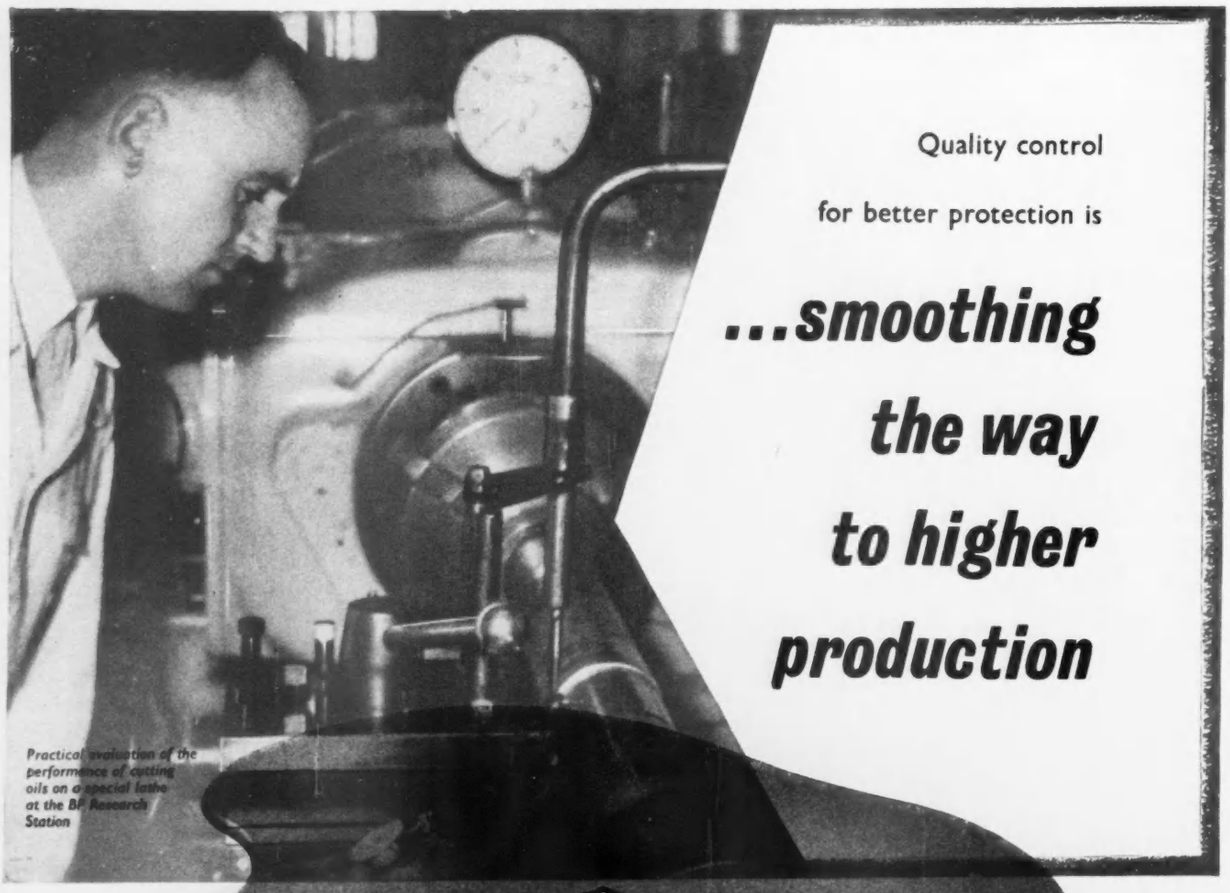

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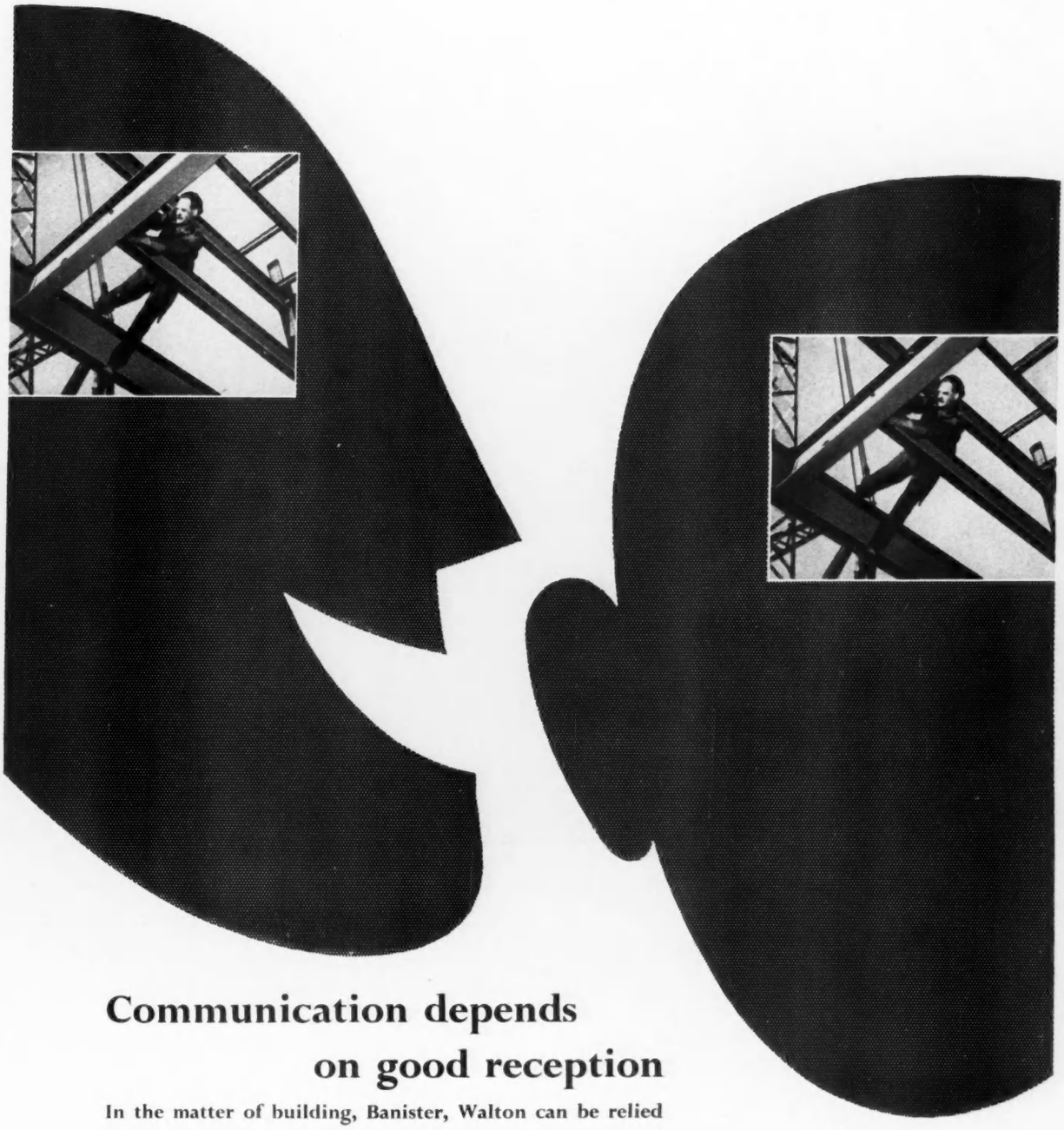

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Illustrated above are three 20 Ton Electric Travelling Ore Unloaders, built by Arrol at General Terminus Quay, Glasgow, for Messrs. Colvilles Limited. The machines have an outreach of 68 feet from the waterside rail and a combined maximum handling capacity of 1,800 tons of ore per hour, discharging on to a conveyor system.

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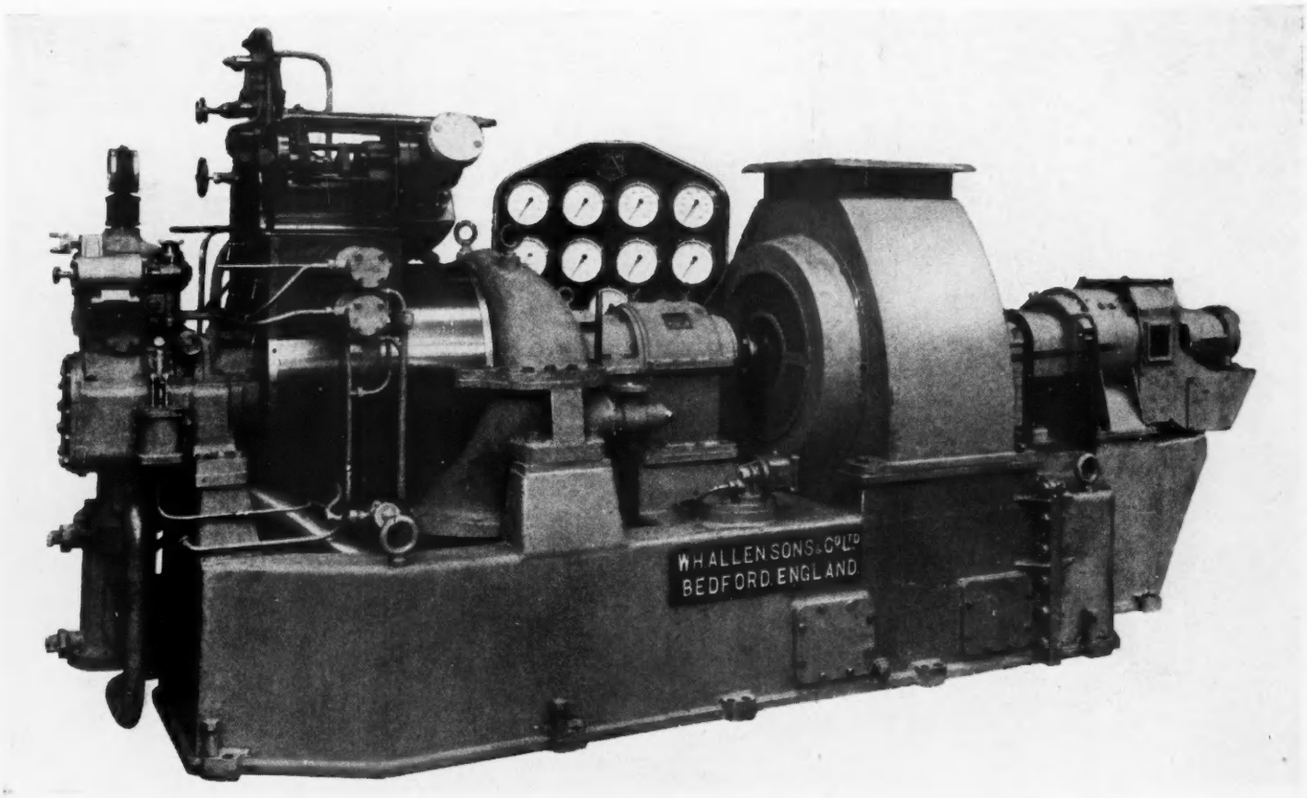

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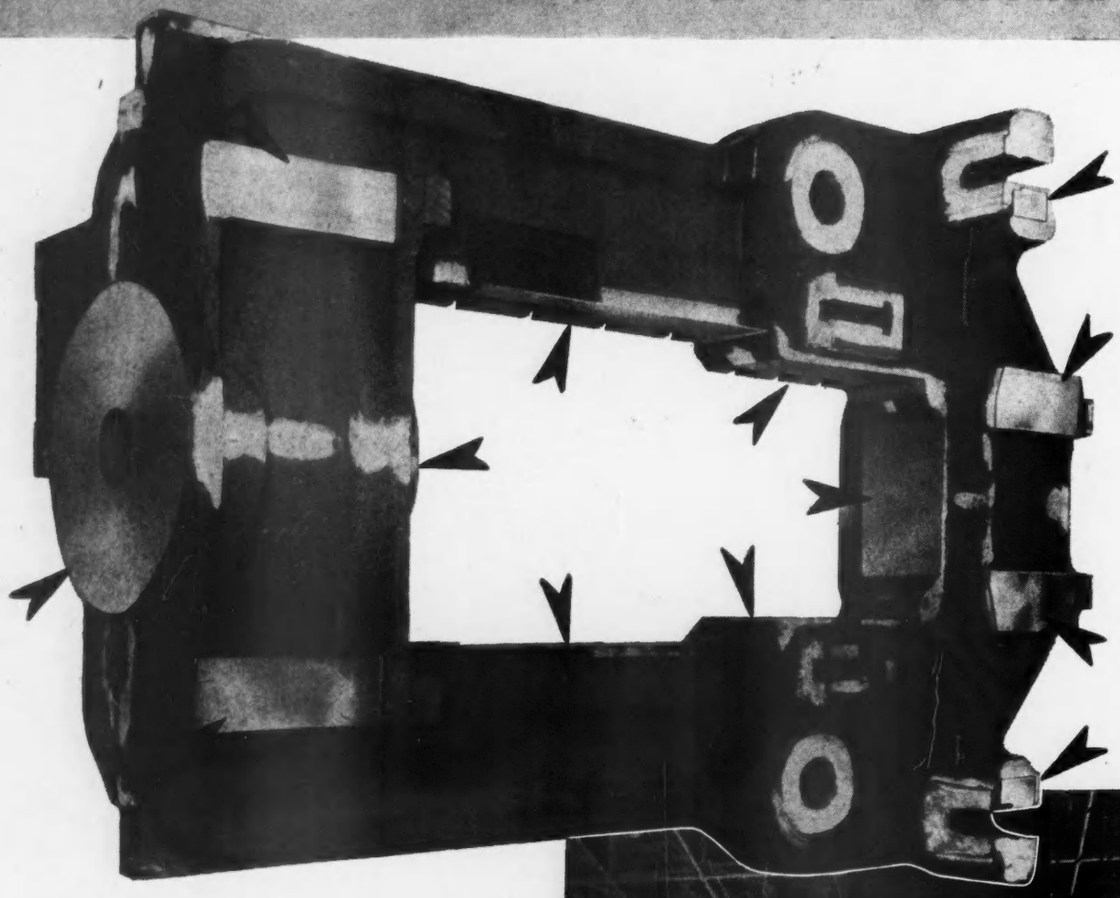

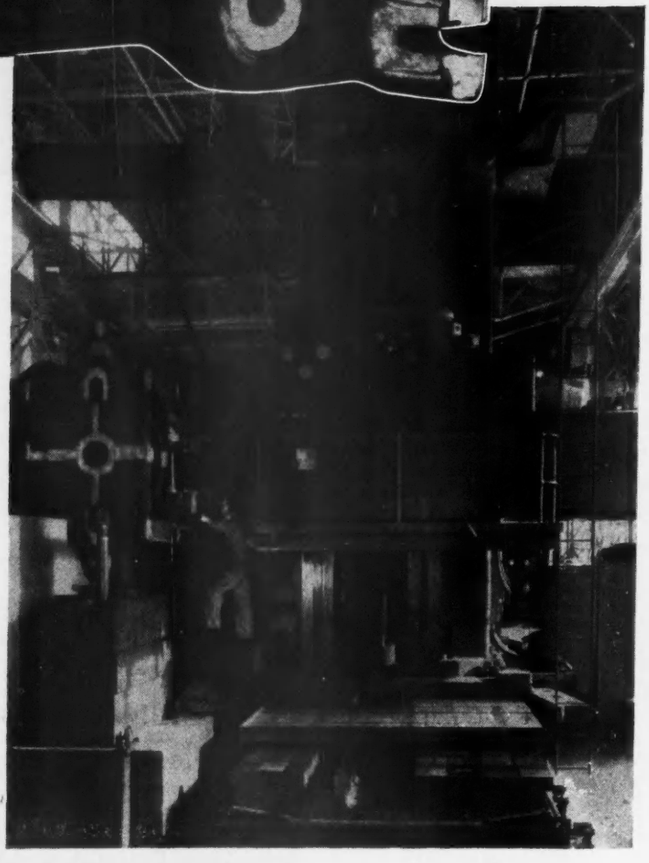

on this ASQUITH *machine*

The illustration above shows a mill housing which has been machined on the end, front and window faces at one setting on the Asquith 7in. spindle Ram Type Horizontal Milling and Boring Machine. Exceptional rigidity and accuracy for heavy duty cutting or match milling is ensured by the 16in. diameter driving flange of the milling sleeve, fully supported by the large section ram. The machine can be operated from the pendant and many new design features such as steering control, for milling surfaces of irregular outline or large circumference, are incorporated whereby this Asquith machine may be regarded as the most up-to-date machine of its type for heavy engineering work.

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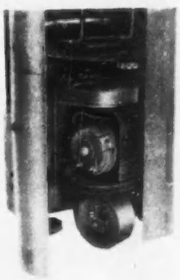

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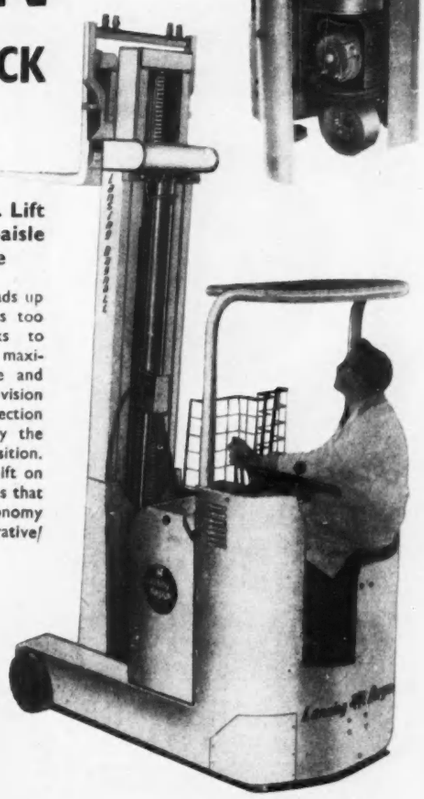

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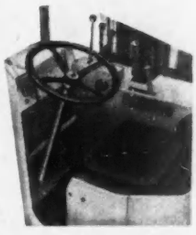

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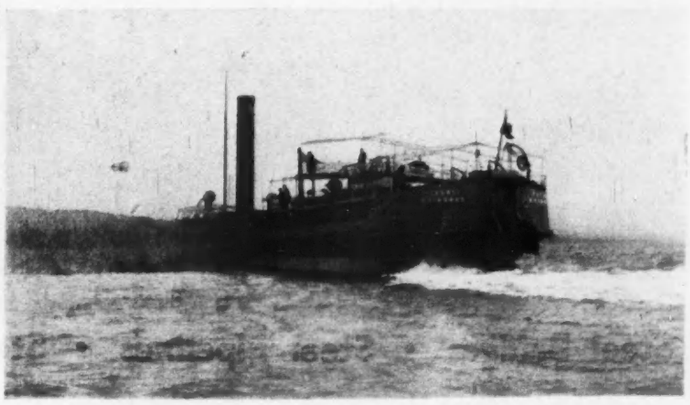

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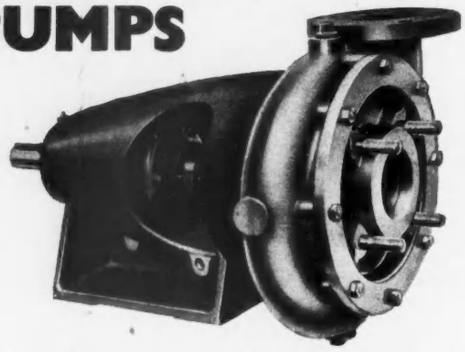

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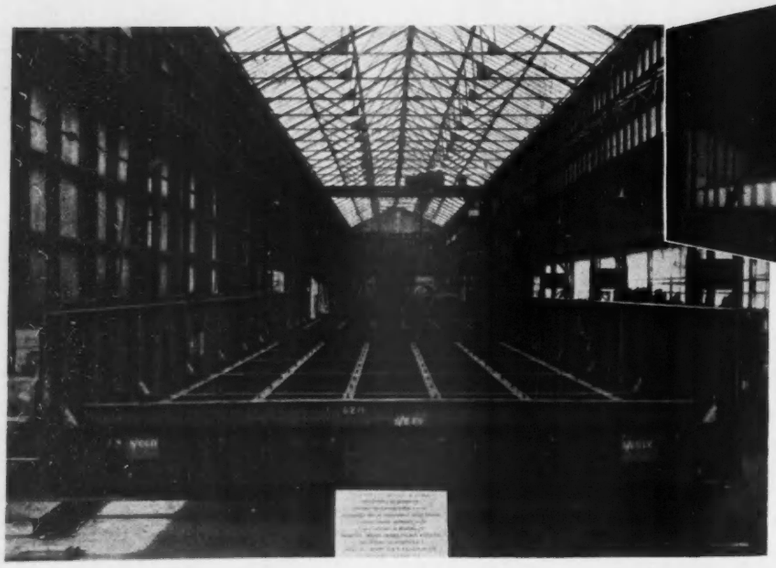

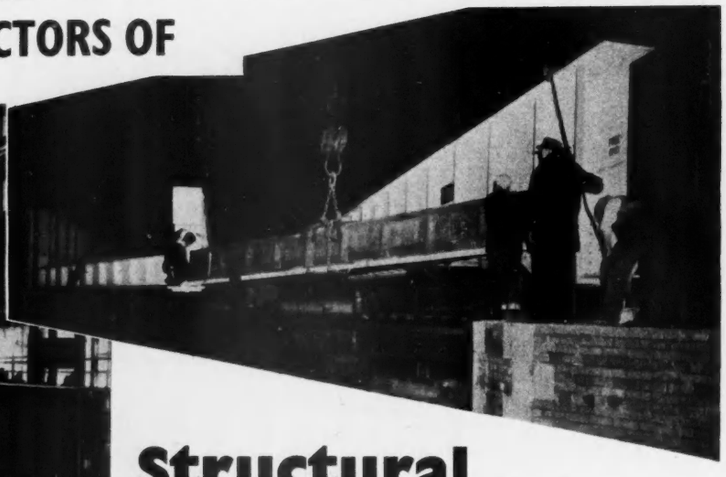

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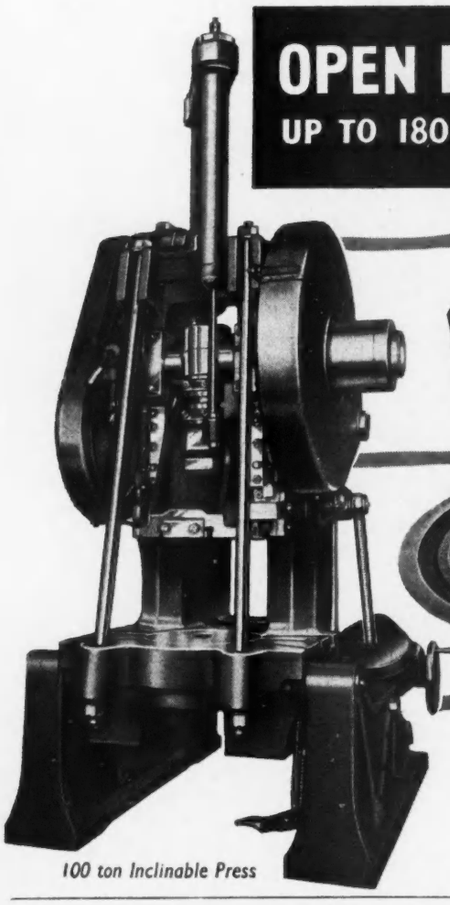

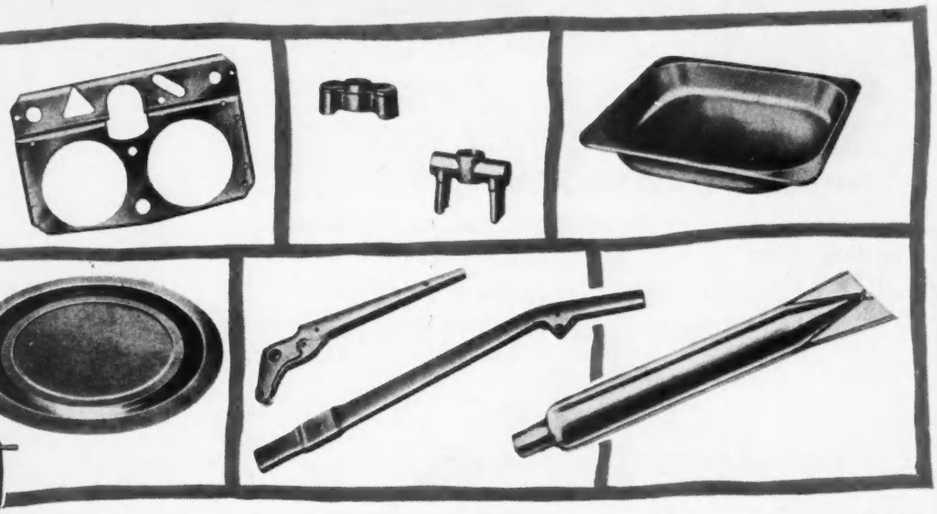

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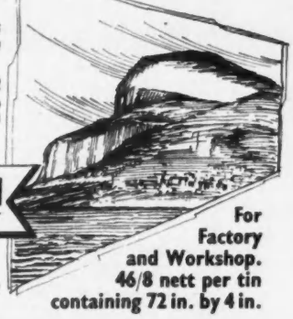

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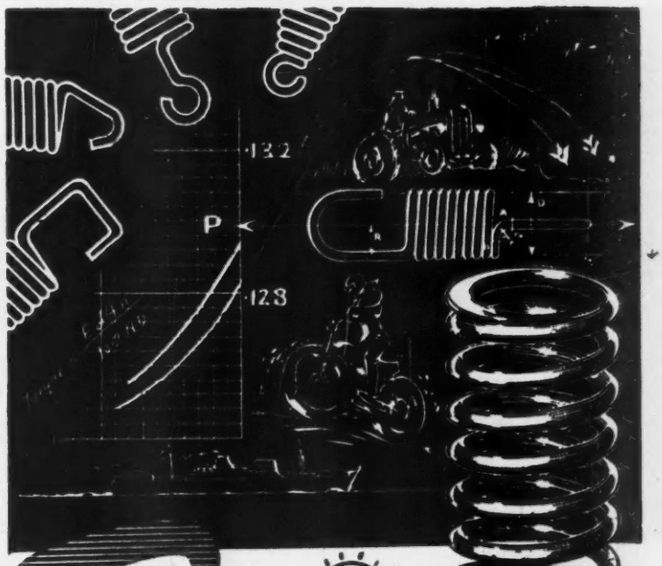

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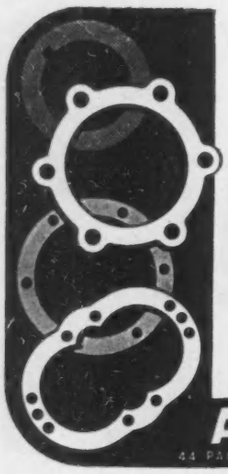

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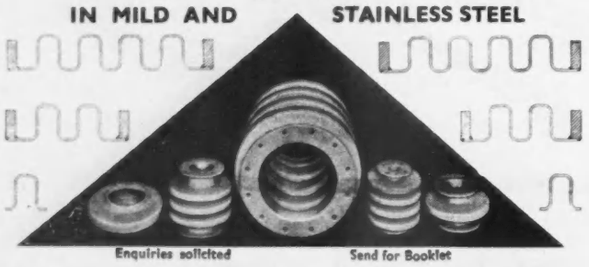

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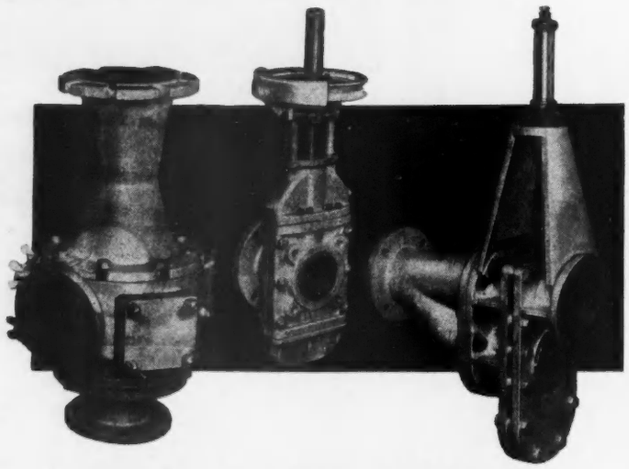

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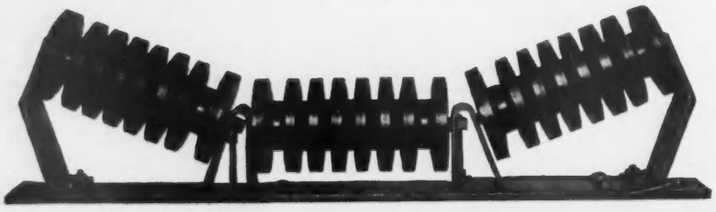

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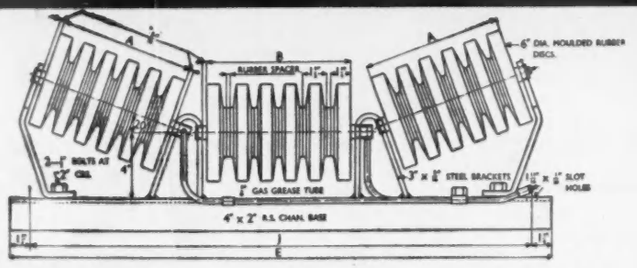

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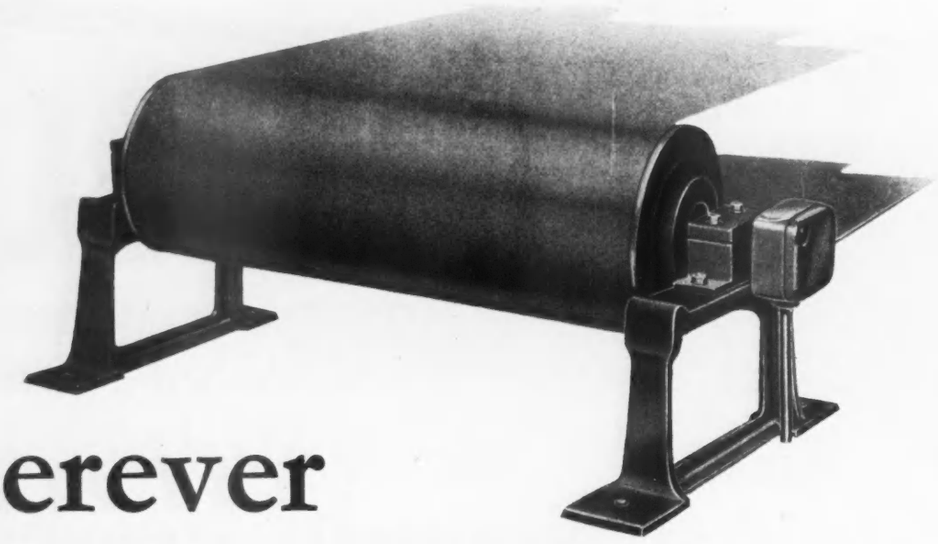

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THE ENGINEER

No. 5379 **FEBRUARY 27, 1959** VOL. 207

JAPAN'S FIRST NUCLEAR POWER STATION

During the past few months there has been a great deal of speculation about the prospective contract for the building of Japan's first nuclear power station. American firms as well as British consortia have been competing keenly for this coveted prize. In this climate of competitive uncertainty there have been diverse crops of rumours and counter rumours and, naturally, most of them have been short lived. However, this week's announcement by Mr. Arnold Lindley, assistant managing director of The General Electric Company, Ltd., of England, signifies that the first definite stage has been reached in the negotiations. For Mr. Lindley stated at a press conference in London that the Japan Atomic Power Company had entered into exclusive negotiations with the G.E.C. and that subject to the satisfactory conclusion of these negotiations it was proposed to issue in a few weeks a letter of intent concerning a contract to build a nuclear power station at Tokai Mura, 65 miles north-east of Tokyo.

As the matter stands at present, anything beyond the fact that exclusive negotiations have been started must be largely conjectural. The G.E.C. - Simon-Carves Atomic Energy Group has indeed published the broad outlines of its proposals, which provide for a power station with a net electrical output of 150MW derived from a single gas-cooled, graphite-moderated reactor of the same basic kind as the two reactors now being built by the group at Hunterston in Scotland. The reactor will be associated with four steam-raising units. In common with the other competing tenders for this project, the design incorporates several novel ideas in structural and control engineering to ensure the safety of the whole installation under earthquake conditions. It was these considerations that prompted one interesting modification ; whereas the Hunterston reactors are arranged for bottom charging of the fuel elements, the Tokai Mura reactor will be top-charged to give a layout with a lower centre of gravity and, accordingly greater stability under earthquake conditions.

If the subsequent negotiations based on these general proposals are taken to a satisfactory conclusion, the G.E.C., as the main contractor, will be responsible for the design of the whole project. Many important details remain to be decided during the negotiations. For example, it is known that, subject to the responsibility of the main contractor for the overall design, many of the individual items of plant will be manufactured by Japanese firms. It is significant, therefore, that the G.E.C. has recently concluded, subject to approval by the Japanese Government, a long-term licensing agreement with a consortium of fourteen leading Japanese companies known by the promising title of the First Atomic Power Industrial Group (F.A.P.I.G.). Members of this group, besides carrying out much of the manufacturing work, will also undertake site construction work under the direct supervision of the British consortium. In this particular the Tokai Mura project will follow much the same pattern as that set by the power station now being built by the Nuclear Power Plant Company at Latina, near Rome. Both schemes are very far from being " turnkey " contracts. Each in great degree is an exercise in collaboration, in which a British consortium supplies the design of the whole installation, together with much of the specialised knowledge and plant, while much of the detailed work is contributed by local industry. This rather novel form of contractual procedure may be fraught with certain difficulties but, as we have previously suggested in these columns, it offers perhaps the best prospects of enabling Britain to help industrial countries to develop nuclear power for peaceful uses. From it may evolve a novel and fruitful form of partnership with worthwhile advantages over the more familiar relationship between supplier and overseas customer.

USING WATER OVER AND OVER AGAIN

During the last three weeks a number of publications have appeared all concerned in one way or another with water supplies, rivers, and water pollution. The first to reach us was the *River Boards' Association Year Book for* 1958 which contains a variety of information about the work of Boards during the year. Next to reach us were two reports from the Central Advisory Water Committee of which we print elsewhere the conclusions and recommendations. One was concerned with " Water Resources," the other with " The Growing Demand for Water." Then on Friday of last week we attended a joint meeting of the Institution of Water Engineers, the Iron and Steel Institute and the Sheffield Society of Engineers and Metallurgists when a visit was paid to the Park Gate Iron and Steel Company at Rotherham to see a water recirculation plant in operation. A paper about it was subsequently read and discussed. Lastly as we go to press there has come to hand the *Surface Water Year-Book of Great Britain* 1956–57. All five documents deal with facets of a single subject.

It is really rather remarkable in a country such as ours whose population makes a heavy demand for a supply of pure water that the means for measuring rainfall and run-off in all but relatively few areas should still remain so very defective. A cursory examination of the *Surface Water Year-Book*, for example, is sufficient to reveal how unsatisfactory the situation still remains. However, largely in consequence of the coming into being of River Boards that situation is being, rather slowly, improved. All engineers concerned with water supply and with hydro-electric works and with river structures in general will re-echo the plea of the C.A.W.C. Sub-Committee on Water Resources for more vigorous action. But though the detail of rainfall and run-off remains hidden there is sufficient broad knowledge to support the other sub-committee's conclusion that the rainfall upon this country is adequate at present to meet all water supply demands. But that conclusion has to be accepted with reservations—including some reservations beyond those that the sub-committee itself is careful to make. The

demand on water supply undertakings is expected to rise by some 23 per cent above the 1955 level by 1965. Probably the amount taken, principally by industry, from private sources (about which, astonishingly, almost no reliable data are available) will rise by a comparable percentage ; but it does need to be borne in mind that ever since the end of the war the industrial demand has been rising at a greater rate than the domestic. Plans are in hand for the necessary works of water supply undertakings though not all have yet been approved by the Minister ; and the sub-committee thinks that capital expenditure may be soon running at some £35,000,000 per year. The sub-committee believes that even after 1965 there will still be large reserves available to meet still further increasing demands. But it does draw attention to one form of demand which it may prove difficult to meet. Water is beginning to be used agriculturally for irrigation. Now much of the water supplied to industry or for domestic purposes is returned eventually to rivers as effluent. But almost none of the water used for irrigation ever gets back into a river again. Moreover the demand, particularly in the South-East of this country where rainfall deficiency in a dry year can reach as much as twelve inches, could become relatively very large. To quote from the report " The demand for irrigation water in certain areas could far exceed the demand made by industrial and domestic consumers combined."

The demand for water is already so high that riparian owners, river boards, fishing interests and local councils with an eye to amenities in many areas are seriously worried about water distribution. Quite obviously, from the report of the sub-committee, they must become even more seriously worried in the future. Means will surely need to be found within the not distant future for economising in the demand for water supply. In certain regions, where there are threats of water abstraction to feed far away cities or industrial regions, those concerned with fisheries or the amenity aspects of rivers would claim that there is need for economy already. One means of economising is that illustrated by the Park Gate Steel Works plant for recirculating water through the rolling mills. It is by no means unique and, indeed, there is a similar plant at Shepcote Lane Steel Works in the same area. Very substantial economies in the demand for water can be realised by re-circulation. But by waterworks standards, as the authors of the paper on the Park Gate plant remark, the cost of treatment of the water in circulation can prove " fantastically " high. It is, of course, true that at Park Gate the capital and running costs of the plant are almost negligible in relation to those of the rolling mill plant served and that the same is likely to be true for many other industrial processes. But where in such figures is there any incentive to industry to economise in the demand for water by adopting recirculation ? It is to be noted that recirculation was, in fact, adopted at Park Gate because the local water undertaking was unwilling to make a sufficient supply available. Another and more promising means of economy arises out of efforts to reduce the pollution of rivers. There ought, we feel, to be more rivers flowing through industrial areas which are kept free of pollution just as the Thames Conservancy keeps the Thames clean enough for it to provide the major part of London's water supply. There can be little clash between utility and amenity if a respectable effluent is put back into a river little below the point at which a supply of water was abstracted from it. But there is a substantial clash if the water is abstracted from upland sources and returned as an effluent far down the river's course or possibly into an estuary or into some different river. In the future, we feel, more and more it will have to be studied when water supply projects are being considered, whether those projects provide for the most economical use of the water, taking into account all possible ways of using it. If water is to be properly conserved projects should be so devised that the water is used over and over again before it reaches the sea.

MIXED BLESSING

One of the ill-effects of the existence of a tax on certain fuels in specific applications in this country is that the small two-stroke cycle internal combustion engine has, in the absence of a really practical fuel injection system, failed to gain ready acceptance. Thus it has come about that British engineers, although ready to claim the invention and perfection of the two-stroke cycle for this country, are to-day hardly aware of the modern state of the art of the engine's design. We have been enlightened to some extent recently by experience with a Goggomobil coupé. The engine displays to the full the expected virtues that enthral the transmission designer, a wide working speed range and a low moment of inertia, while creating immense confidence in the operator by the instant, seemingly effortless starting, hot or cold, given by the dynamotor. One limitation there is, however, that may be deemed onerous ; the operator is advised that during the course of a long descent on engine braking, the engine lubrication should be restored by disengaging the clutch and temporarily opening the throttle. This requirement might be acceptable enough if only the electromagnetic dry particle clutches introduced from the United States to this Continent had fulfilled their initial promise as highly controllable transmission components—no clutch could better match the electrically controlled selective gearbox of this rear-engined car—but it is an unpleasant reminder that petroil lubrication commits an engine designer to an unsophisticated fuel system in which the efficiency must be allowed to go negative.

The limitations of this system of lubrication could be perceived in the paper presented lately to the Automobile Division of the Institution of Mechanical Engineers by Mr. A. Towle. We do not reproduce the paper, since it was somewhat devoid of detail of value to engine designers or vehicle operators, but it may be said that it amply confirmed the superiority, at least for crankcase-compression engines, of the solution of Alfred Scott, in which the oil is metered through the main bearings and the feed is controllable with a reasonably short time constant. This principle is probably widely applicable to machines that are driven rather than ridden, since the control effort needed to regulate air, fuel and lubricant flows together would probably be large, so it may be that, as Mr. Towle suggests, petroil will persist on carburetted engines. If so, an onerous problem is encountered. Lubricant performance often determines the tolerable temperature of the exhaust port walls, and hence, at least amongst air-cooled designs, the allowable loading of the engine. But on motor-cycles, where tankage capacity is severely limited, a catholic appetite for consumable oils is mandatory; but even the most popular of oils is not available at all filling stations, and for many hours each day there are all too few places to buy petroil. Where oil does not suffice, either for lack of performance or difficulty of delivery, one looks to-day to molybdenum disulphide, tempted by the thought of some highly concentrated additive of which sufficient for many tankfuls of fuel could be stored and transferred when needed by a positive displacement pump, the while, perhaps, some oil with no quality other than a high enough

viscosity was added for the protection of the bearings. But molybdenum disulphide, of course, is no panacea. We were recently presented with an admirably documented report showing that the addition of the boundary lubricant to the sump oil alone would not, in the case of an M.G. " Magnette " with a highly qualified driver, give a ring and a bore life in excess of 36,000 miles. But molybdenum disulphide is now available down to wavelength-of-light particle sizes (virtually colloidal solutions in light oil) which can be injected harmlessly by a carburetter and should give ideal upper cylinder lubrication—certainly the output limitations of air-cooled engines with chromed light alloy blocks have been raised thereby. While it remains our view that the time has come to develop more ambitious two-stroke engines, modern lubrication techniques should be able to extend greatly the usefulness of mixture-compressing units.

UNWANTED CANALS

Last August, we commented in these columns on the report of the Committee of Inquiry into Inland Waterways, which had just been published at that time. The Government has now published a White Paper, outlining its proposals, following this report. These proposals are described as " trying out experimentally some of the Committee's ideas." An interim policy for about two years is proposed to try out the Committee's suggestions, so that permanent legislation can be guided by the experience thus gained, and " to enable action to be taken in urgent cases." A committee to advise on the redevelopment of inland waterways is to be set up, and the Government urges that all users of the " Class C " canals (i.e. those canals considered a " dead loss " for transport but which, it has been pointed out, " have other uses wholly unconnected with transport ") should co-operate in reviewing the waterways in which they are interested so that concerted redevelopment schemes may be introduced. A limited system of financial grants is suggested, but the general principle emphasised is that those who benefit should pay. The " Class A " waterways which are commercially sound clearly present no problem as far as the Government is concerned, and of the " Class B " or borderline ones, still used for transport but at a loss, it is stated : " a guarantee of continued availability for commercial navigation for twenty-five years of the whole 900 miles of these waterways cannot be given at this stage, although every effort will be made to preserve the system as far as is practically possible."

The White Paper asserts that " the report opens up a prospect of fresh action on canals and it is the Government's aim in initiating these proposals to make it possible for all those concerned to make a start in a new atmosphere, first in the field of redevelopment." This may seem a little pious to the canal enthusiasts, who will not have forgotten that the first report along these lines was published (by the British Transport Commission) in the spring of 1955. The Government's Bowes committee was formed nearly a year later, and as we have already noted, it reported last August. That committee's report, however, revealed fundamental disagreement about the principles of ownership and management of the canals. With this difficulty, the Government might well have shelved the whole matter. The proposals now made public, although cautious and limited, do, in fact, " open up a prospect of fresh action," and that is really all that can be expected.

A WEATHER SATELLITE

It is now less than eighteen months since the Russians startled the world by flinging an artificial satellite—" Sputnik " No. 1—into an orbit around the earth. But in that short space of time so many more satellites have been set up in orbits that no banner headlines now adorn the pages of the daily press each time a new satellite rocket is successfully fired. Last week, indeed, the fact that a new satellite had been set up by the Americans was hardly regarded as front-page news. Yet, technically, the affair was not without special interest because effectively it marked the successful outcome of the " Vanguard " project which received so much publicity before the Russians put their first " Sputnik " into orbit. The satellite now in orbit appears, in fact, to be very similar to that which was described in the world's press during the early part of 1957. It is 20in in diameter and weighs 21 lb. Perigee of the orbit of the satellite is 335 miles above the earth and apogee over 2000 miles up, figures which suggest that the object will remain in orbit for a very long period if not for ever. The track lies at an angle of 35 deg. to the Equator and the period is 126 minutes. The purpose of this satellite named " Vanguard II " (" Vanguard I," it will be remembered, is the size of a grape-fruit) is to provide some information about the earth's weather. Two photo-electric cells are recording the intensity of the light reflected from the earth's surface. Since clouds reflect more light than land or sea surfaces, the satellite should be able to detect the presence or absence of cloud masses in the various regions over which it passes during the daytime. The information is being stored and transmitted to earth once in each revolution. Unfortunately, the instruments are not expected to continue working for more than a month, so that the information collected must be of limited value.

The Engineer—100 Years Ago (FEBRUARY 25, 1859)

" The Great Mortar "

" Much as has been said of the great mortar, its real merits have been but imperfectly understood until the recent appearance of Mr. Mallet's able paper upon ' The Military and Naval Uses of very large Shells, and the Comparative Powers of Shells in relation to Diameter.' Our readers will not have forgotten the general results of the great mortar trials at Woolwich, October 19th, 1857. On that day, Mr. Mallet's mortar accomplished—what had never before been achieved in gunnery—the projection of a shell weighing 2,548 lb. to a distance of more than a mile and a-half, and its penetration at that range to nearly 20 ft. in solid earth. A result like this might have decided a siege, for the shell had a capacity to carry 480 lb. of powder, which, by its explosion at the maximum penetration, would have blown out a crater more than 40 ft. in diameter. The line of descent was 20 deg. from the vertical, but the maximum projecting charge of 120 lb. of powder, for which the mortar chamber was bored—only 70 lb. having been used at the range of 2,644 yards—would have carried the shell probably 4,500 yards, a range at which its fall would have been nearly vertical, and its penetration at least 25 ft.

" No citadel on earth could have sustained for a single day a continued fire like this. Each shell, 3 ft. in diameter, was indeed a huge transferable mine, containing, when in flight, a momentum sufficient to carry it through the heaviest earthworks, deeply buried in which its explosion would remove more than 20,000 cubic feet of earth and dislocate the heaviest mass of superincumbent masonry. . . . We understand that further trials of the great mortar are contemplated ; and we heartily wish, as must every Englishman, that they may realise all the anticipations which were awakened by the results of the first trials."

Shape Factors and Functions in Rubber Engineering

By A. R. PAYNE, B.Sc., A.Inst.P.*

No. 1

This article† describes experiments to determine the form of the stress/strain relationships in compression for flat rubber pads of circular, rectangular, and square cross sections as well as pads of circular cross section with a central hole, under static and dynamic conditions and under bonded or lubricated conditions. The effect of fillers in the rubber composition on these relationships is discussed. Next, the static and dynamic stress/strain relationships for a rubber mounting deformed in shear are considered, and the experimental results shown to be in conformity with the theory derived from classical elasticity theory. The shape function and shape factor of a shear mounting are discussed. From a combination of the shape functions in shear and in compression, a theoretical expression for the stress/strain relationship for a combined shear and compression mounting is derived which agrees well with experiment.

MANY manufactured rubber articles are used in compression, notably tyres, railway buffers, and many types of anti-vibration unit, but the design of rubber units for anti-vibration or shock absorption work for mountings and vehicle suspensions has been hampered by the lack of a rigorous mathematical theory of rubberlike elasticity applicable to the types of large deformation met with in service. Similar remarks apply to shear. The reasons for the lack of a comprehensive theory are : (i) Lack of proportionality between compressive stress and strain ; (ii) Effect of the shape and dimensions of the compressed rubber ; (iii) Effects of stress history or a stress-time factor and of hysteresis upon the stress-strain relationship ; (iv) The wide variety of shapes met with in service. It is the experimental complexity introduced by the above phenomena that has made shape factor problems a major stumbling block in the design of rubber components. However, a number of studies, Ariano (1928), Haushatter (1931), Keys (1937), Downie Smith (1938), Kesten (1938, 1948), Cain (1940), Kimmich (1940), Downie Smith (1941), Jenkins and Cooper (1948), Schay and Szor (1952), and Davies (1953) have been undertaken with a view to relating the apparent compressional stiffness to shape factors, where the shape factor is a function of the size and shape of the compression pad. Various of the above references may be consulted for the evidence that (i) similarly shaped pieces of rubber give the same percentage deflection with equal compressive stress, i.e. loads proportional to cross-sectional area ; (ii) the nature of the loaded surface greatly influences the stress required to produce a given compressive strain.

In the literature the expression " shape factor " has been most frequently applied to the ratio loaded area/free area. As, however, the observed strain for one shape is not obtainable from that for another shape merely by multiplying by a factor, it is preferable to refer to " shape function " which contains some function of the shape of the rubber and the deformation.

Notation.

A, A_1, A_2—Material constants, dimensionless.
B, B_1—Material constants, dimensionless.
C—Spring constant, pound per inch.
E—Apparent Young's modulus, pound per square inch or dyne per square centimetre.
E_D—Apparent dynamic Young's modulus, pound per square inch or dyne per square centimetre.
E_e—Real Young's modulus, pound per square inch or dyne per square centimetre.
F—A shape factor—ratio of area of one loaded face/force free area (only in Part I of paper).
F_1—Force on one spring, pound, Part III of paper.
F—Shear load, pound, in Part II and III of paper.
F_T—Total imposed force, pounds.
G—Shear or rigidity modulus, pound per square inch or dyne per square centimetre.
G_A—Apparent shear modulus, pound per square inch or dyne per square centimetre.
G^*—Complex dynamic shear modulus, pound per square inch or dyne per square centimetre.
G^1, G_D—Real part of the dynamic shear modulus, pound per square inch or dyne per square centimetre.
G^{11}—Imaginary part of dynamic shear modulus, pound per square inch or dyne per square centimetre.
G_{DA}—Apparent dynamic shear modulus, pound per square inch or dyne per square centimetre.
G_U—Shear modulus of non-filler loaded rubber, pound per square inch or dyne per square centimetre.
G_F—Shear modulus of filler loaded rubber, pound per square inch or dyne per square centimetre.
H—Dynamic strain, dimensionless.
k—Radius of gyration.
P—Compressive load, pounds.
X_1—Bending displacement, inches or centimetres.
X_s—Shearing displacement, inches or centimetres.
a—Cross-sectional area, square inches or square centimetres.
b—Breadth of pad, inches or centimetres.
d—Vertical displacement of spring.
d_c—Compressive displacement, inches or centimetres.
d_s—Shearing displacement, inches or centimetres.
e_h—Strain in the height direction, dimensionless.
e_b—Strain in the breadth direction, dimensionless.
e_l—Strain in the length direction, dimensionless.
f—Stress.
f_c—Stress, compression, pound per square inch or dyne per square centimetre.
f_{cu}—Stress, compression of non-filler loaded rubber, pound per square inch or dyne per square centimetre.
f_{cF}—Stress, compression of filler loaded rubber, pound per square inch or dyne per square centimetre.
h—Height of pad, inches or centimetres.
k—Material constant, dimensionless.
l—Length of pad, inches or centimetres.
m—Material constant, dimensionless.
r, r_1, r_2—Radius ; r_1 internal, r_2 external, inches or centimetres.
Φ—A shape function, dimensionless.
χ—Angle of shear.
ψ—Phase angle.
δ—A shape factor, dimensionless.
λ, λ_0—Ratio of compressed height of pad to initial height. (λ_0 . static precompression), dimensionless.

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† R.A.B.R.M. Research Report No. 84, "Dynamic Properties of Vulcanised Rubber : 5," Part I, is a continuation of R.A.B.R.M. Research Report No. 77.

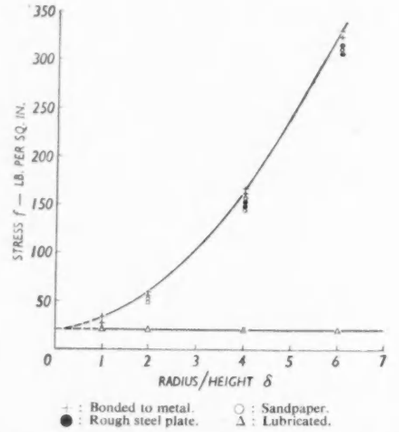
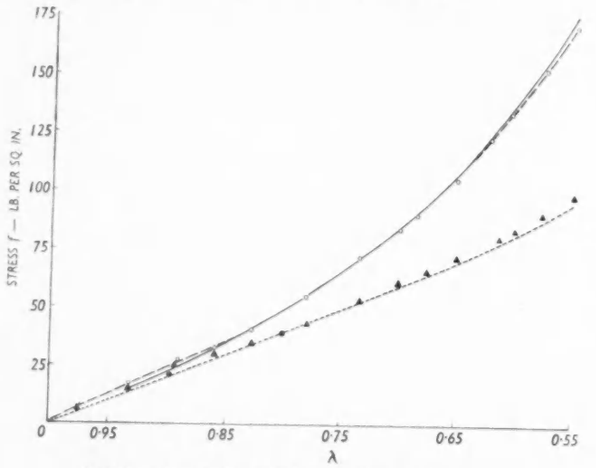


Fig. 1—Effect of various surfaces on the stress at 10 per cent compression for cylinders of the same rubber of various radius/height ratios (Mix A, see Appendix I)

The statistical theory of rubber-like elasticity gives for the stress f_c at a relative compressed height λ :

$$f_c = G(\lambda - \lambda^{-2}) \quad . \quad . \quad . \quad . \quad (1)$$

where G is the shear modulus (Treloar, 1949). Examination of the data plotted in Fig. 2 gives 62·0 lb per square inch as the value of the shear modulus giving the best fit of equation (1). Also plotted on Fig. 2 are the experimental results referred to the actual cross-sectional area, and the fitted curve to them is that given by $f_c = G(\lambda - \lambda^{-2})/\lambda$,



Solid line : Theoretical curve. Circles : Experimental points.
Triangles : Stress referred to actual cross section.

Fig. 2—Stress-strain curve for natural rubber : comparison of practical values with the statistical theory, equation (1)

where G, as before, is 62 lb per square inch. It is seen that at high values of λ the experimental values are slightly above the theoretical line, as is expected by the appearance of barrelling in the test specimen. However, this additional stress due to tractions in the curved surface can be ignored when λ is greater than 0·60 and is probably unimportant for many purposes at even lower values.

Summarising, we may say that for perfectly lubricated flat pads of any cross section either the stress or strain can be calculated by simple theory if one of these parameters is fixed.

PART I : COMPRESSION

Lubricated Circular Flat Pads

Fig. 1 shows the effect of various surfaces on the stress at 10 per cent compression and that silicone grease gives an extremely well-lubricated surface, the stress being independent of the shape factor. Using this method of lubrication, measurements of stress, strain, and lateral expansion were made on a natural rubber pure gum vulcanisate, the force being obtained for steps of 0·020in increment in displacement thirty seconds after application of the strain. The results are shown in Fig. 2. No hysteresis was observed, the measured stress for both increasing and decreasing strain falling on the same curve.

Bonded Circular Flat Pads

For bonded circular pads, as already indicated (Payne, 1956), the form of the stress/strain relation is :

$$f_c = G\Phi = G \cdot f(\lambda, \delta) \quad . \quad . \quad . \quad (2)$$

where, in addition to terms previously used, $f(\lambda, \delta)$ represents a function of strain ratio λ and shape factor δ, and is called the " shape function." Shape factor is here defined as a suitable ratio of the initial specimen dimensions, e.g. for circular pads the ratio of the radius (r) to the height (h) of the pad. Φ should be a purely geometric term, whilst G specifies properties peculiar to the rubber and the speed of test.

The stress/strain curves for bonded circular pads of various values of shape factors were obtained using a pure gum natural rubber vulcanisate. The values for particular λ and δ were obtained from the stress/strain curves by dividing the stress by G, derived from the linear relationship (equation (1)) between stress and $(\lambda - \lambda^{-2})$ for the rubber compressed between lubricated plates. The values of Φ are plotted in Fig. 3 against the square of the shape factor (δ) for compressions of 5 to 50 per cent of the initial height, i.e. λ values of 0·95 to 0·50. The bonding was efficiently performed by cyclisation of the rubber surface followed by cold cementing to mild steel with Araldite 103 (Aero Research Ltd., Duxford, Cambs) and the same cylinders were used as for the lubricated experiments.

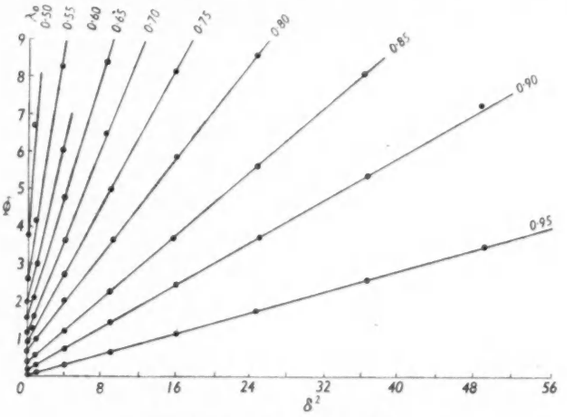


Fig. 3.—Φ versus δ^2 for cylinders

Examination of the data given in Fig. 3 confirms that Φ is a linear function of the square of the shape factor and can be represented by

$$\Phi = (\lambda - \lambda^{-2})(1 + k\delta^2) \quad . \quad . \quad . \quad (3)$$

where k is an empirical constant with a value of 0·413 obtained by fitting the curves to the data ; k for a lubricated pad is zero.

The stress/strain equation for bonded circular pads is therefore,

$$f_c = G(\lambda - \lambda^{-2})(1 + k\delta^2) \quad . \quad . \quad . \quad (4)$$

with $k = 0{\cdot}413$.

It can be shown that equation (4) fits the data reported by Parkinson and Gough (1941) and Schay and Ször (1952) at least as well as the empirical formulæ used by them. In the latter case fitting equation (4) with $k = 0{\cdot}413$ leads to shear modulus between 7·5 kg or 7·7 kg per square centimetre. Fig. 4 shows the experimental results of Schay and Ször for a natural rubber mix with 20 parts of carbon black (type unspecified) ; it can be seen from the fitted curves that, within a few per cent, equation (4) adequately describes the experimental results.

Square Cross-Section Flat Pads

Experimental work for compressive strains up to $\lambda = 0{\cdot}50$ and with shape factors from 0·25 to 6 has been carried out on lubricated and bonded square cross-section pads. It is convenient to define the shape factor, by analogy with that for the cylinder, as the ratio half breadth/height. The results for lubricated ends are in accord with equation (1) and independent of the shape factor. Those for bonded ends are adequately described by equation (4), in which, by fitting the curves, a value of 0·525 is inserted for k. Equation (4) with this factor was accordingly used with the data reported by Hattori and Takei (1950), who investigated six lubricated and bonded square flat pads with shape factors (S) from 0·46 to 3·67. These authors, by classical theory assuming small deformations, found Young's modulus,

$$E = E_0(1 + k\delta^2) \quad . \quad . \quad . \quad . \quad (5)$$

where E_0 is the value of E extrapolated to zero shape factor, and k is a constant. This deals only with very small compressions and the coefficient k is incorrect; however, the use of equation (4) enables a value for the shear modulus (see Table I) to be deduced from their experimental data and its constancy affords a convenient test of the goodness of fit of equation (4) to the data.

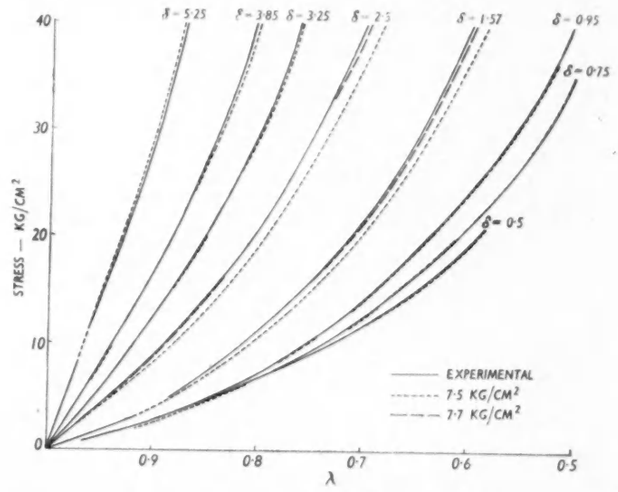


Fig. 4—Experimental results of Schay, *et al*, compared with the theoretical curves obtained from equation (4)

TABLE I—*Shear Modulus Calculated from Data by Hattori and Takei*

Shape factor	Shear modulus from equation (4), kg/cm²
0·46	14·3
0·58	15·3
0·88	15·1
1·19	15·7
1·735	14·9
3·67	14·7
Mean	15·0

Hattori and Takei quote 15·3 kg per square centimetre as the shear modulus of the rubber, a figure which is derived by taking one-third of the compression modulus at small strains with lubricated ends. It may be taken, therefore, that the data can be accurately expressed by equation (4), using the same value of the constant k (0·525) as was obtained in the present work.

Bonded Rectangular Cross-Section Flat Pads

Where all the axes of the rectangular flat pad differ in length the shape factor cannot be unambiguously defined by a single ratio, but the following analysis has been found to agree with the experimental data.

If e_h, e_b and e_l are the strains in the height, width and length directions of a rectangle of height h, breadth b, and length l, and assuming that on compression the strains in the length and breadth are inversely proportional to the initial length and breadth, then :

$$e_l = e_b b/l \quad . \quad . \quad . \quad . \quad . \quad (6)$$

At small strains and assuming constancy of volume,

$$e_{hl} = e_l + e_b = e_b(1 + b/l) \quad . \quad . \quad . \quad (7)$$

where e_{hl} is the compressive strain for a rectangle allowed to expand in both the breadth and length directions.

If the length deformation is restrained then the rectangle approximates to the infinite-length rectangle condition. It is axiomatic that due to the greater lateral deformability of the finite length strip the compression for a given stress is larger than for an infinite-length one. Assuming that in the restrained condition a fraction n of the previous increase of length now leads to a further increase in breadth, the fraction $(1-n)$ decreases the effective compression strain below e_{hl}.

Defining the increase of breadth e_{b2} due to lengthwise restraint as

$$e_{b2} = ne_l = ne_b b/l \quad . \quad . \quad . \quad . \quad (8)$$

then

$$e_{h2} = e_b(1 + nb/l) \quad . \quad . \quad . \quad . \quad (9)$$

where e_{h2} is the compression strain for the infinite-length condition.

From classical elasticity theory and potential energy considerations it can be shown—Rocard (1937), Hattori and Takei (1950)—that at very small strains

$$E = E_0(A + B\delta^2) \quad . \quad . \quad . \quad . \quad (10)$$

where A is the variation of the effective Young's modulus E for rectangles of small shape factor with the breadth/length ratio of the rectangle, and is defined as the ratio of the stress of an equivalent infinite-length rectangle of the same shape factor, to the lubricated stress at the same strain. Shape factor δ is here defined as the half breadth/height ratio to be consistent with the definition of shape factor for a square prism. $B\delta^2$ is the necessary correction to the lubricated stresses to account for the bonded condition, and B was shown to vary from $B' = k$ for the square prism to $B' = 2k$ for an infinite-length rectangle with the same breadth/height ratio. The value of B' for a square prism is 0·525, and 1·05 for the infinite-length rectangle. The value of B will vary

according to the breadth/length ratio of the rectangle between these two values, and similar variation will occur in A.

Analogous to the equations (4) and (10), the general stress/strain relationship for a rectangle becomes

$$f_c = G(\lambda - \lambda^{-2})(A + B\delta^2) \quad . \quad . \quad . \quad (11)$$

where A and B are coefficients which depend on b/l and will be derived below, and $\delta = \frac{1}{2}$ breadth (b)/height (h).

At small shape factors, i.e. as δ approaches zero,

$$f_c/GA_1 \simeq e_{b1} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

$$f_c/GA_2 \simeq e_{b2} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

for a rectangle of rubber with a shear modulus G. The suffixes "1" and "2" refer to a rectangle free to expand in the length and width directions, or to the equivalent infinite-length rectangle respectively. Then from equations (7), (9), (12) and (13),

$$A_1 = A_2(1 + nb/l)/(1 + b/l) \quad . \quad . \quad (14)$$

A long thin rectangular strip of $\delta = 0{\cdot}125$ was first compressed by 10 per cent of its initial height between lubricated platens, and afterwards bonded and again compressed by 10 per cent, and the stress ratio of bonded to lubricated specimens noted. The stress ratios for different breadth/length ratios were obtained by varying the length of the rectangle by cutting away incremental strips. The derived experimental values of the stress ratio are shown plotted in Fig. 5 against length/

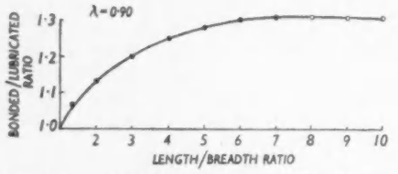


Fig. 5—Bonded/lubricated ratio at $\lambda = 0{\cdot}90$ versus length/breadth ratio

breadth ratio (not against breadth/length, for convenience in plotting) from which it can be seen that the bonded/lubricated ratio increased from 1 to 1·30 for a b/l change from 1 to 0·1. The best fit of equation (14) to the experimental results gives $A_2 = 1{\cdot}37$ and $n = 0{\cdot}47$, i.e.

$$A_1 = 1{\cdot}37(1 + 0{\cdot}47b/l)/(1 + b/l) \quad . \quad (15)$$

If it is assumed that the manner in which B changes with b/l is similar to that in which A changes with b/l, then

$$B_1 = 1{\cdot}05(1 + 0{\cdot}02b/l)/(1 + b/l) \simeq 1{\cdot}05/(1 + b/l) \quad . \quad . \quad . \quad . \quad . \quad (16)$$

Dropping the suffixes to A and B in equations (15) and (16), the stress/strain relationship for a rectangle is expressed by equation (11). For the square pad $b/l = 1$, $A = 1$ and $B = 0{\cdot}525$; for the infinite-length rectangular pad $b/l = 0$, $A = 1{\cdot}37$ and $B = 1{\cdot}05$.

To check the manner of the increase of the coefficient of δ^2 from 0·525 to higher values with increasing length/breadth ratio, two rubber pads of the same high δ^2 were prepared, i.e. breadth/2 × height = 5, one a rubber pad of square cross section, and the other a rectangle with a length/breadth ratio of 10. It was found that the ratio of the stress at 10 per cent compression was 1·73, compared with 1·78 expected by the ratio of equations (4) and (11) when the appropriate constants are inserted.

For practical purposes, little error would be caused if equations (15) and (16) were amended to :

$$A = 1{\cdot}33(1 + 0{\cdot}5b/l)/(1 + b/l) \quad . \quad . \quad (15a)$$

$$B = 1/(1 + b/l) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16a)$$

Equation (15a) is what would be expected if rubber were completely incompressible with $n = 0{\cdot}5$ and the slight differences between equations (15) and (15a) may well be due to experimental difficulties.

Fig. 6 plots the experimental values of stress against λ for a rectangle of rubber of initial $b/l = 0{\cdot}2$ and $\delta^2 = 1{\cdot}24$. The rubber was bonded to metal plates, and after each stress/strain curve, b/l was increased by cutting away the metal plates and the rubber. Prior to bonding, the stress/strain curve was obtained for the lubricated condition.

Table II gives in column 1 the b/l ratios, column 2 tabulates the appropriate function

TABLE II—*Constancy of $f_c/(A + B\delta^2)$ at $\lambda = 0{\cdot}80$ for Rectangles with Various b/l Ratio*

1 b/l	2 $(A + B\delta^2)$	3 f_c at $\lambda = 0{\cdot}8$ lb/in²	4 Ratio $f_c/(A + B\delta^2)$ at $\lambda = 0{\cdot}80$, lb/in²
1·00	1·65	114	69
0·84	1·76	124	71
0·709	1·86	134	72
0·617	1·91	140	73
0·535	1·98	147	74
0·476	2·04	153	75
0·333	2·19	160	73
0·200	2·38	178	74

$(A + B\delta^2)$, and column 3 the stress at $\lambda = 0{\cdot}8$ obtained from the experimental results. Column 4 gives the stress at $\lambda = 0{\cdot}8$ divided by $(A + B\delta^2)$. All the curves in Fig. 6 are linear with respect to $(\lambda - \lambda^{-2})$. An inspection of the results in column 4 reveals that although the stress f_c at $\lambda = 0{\cdot}8$ increases with decreasing b/l ratio, the ratio $f_c/(A + B\delta^2)$ is a constant, i.e. from equation (11) :

$$f_c/(A + B\delta^2) = G(\lambda - \lambda^{-2}) \quad . \quad . \quad (17)$$

The stress of the lubricated square, $b/l = 1$, at $\lambda = 0{\cdot}8$ is seen from the curve in Fig. 6, to give $f_c = 71$ lb per square inch, which compares with the values quoted in column 4.

The shape factor $F = l^2/4lh$ where l = length h = thickness for square-sectioned rubber

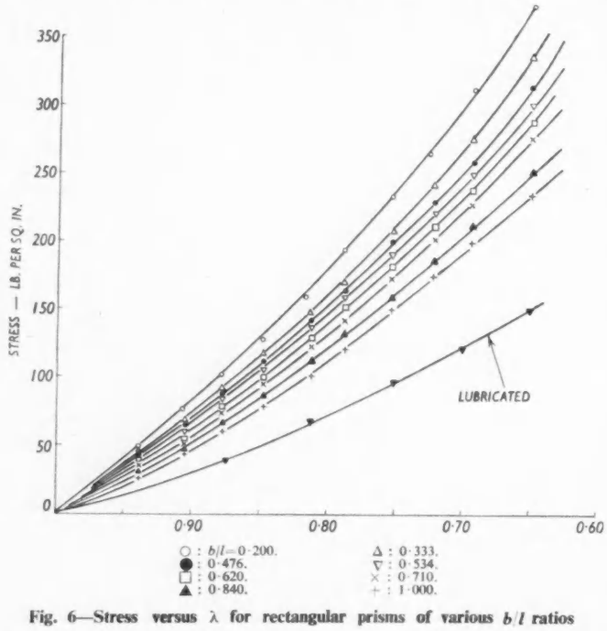


Fig. 6—Stress versus λ for rectangular prisms of various b/l ratios

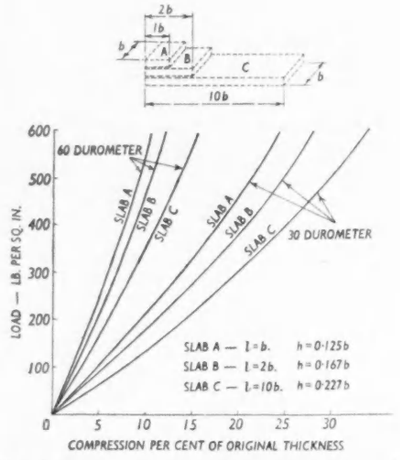


Fig. 7—Load versus percentage compression of original thickness for rubbers of the same F values

was proposed by Keys 1937, the definition is based on the ratio of the area of one loaded face to the free area of the rubber. The free area being the area that is free to distort. The objection to this factor is that rubber of widely different dimensions, but having the same F value, shows widely differing stress/strain properties. This is illustrated in Fig. 7. Table III shows that the shape function proposed here predicts a constant modulus for the rubber (as shown by the term $G(\lambda - \lambda^{-2})$ in Table III), as, of course, it should.

Circular Cross-Section Flat Pads with a Central Circular Hole

Only Kimmich (1940) has previously dealt with the effect on the stress/strain properties of holes in cylinders and in square and rectangular flat pads, but as there are numerous applications in which holes are present in the compression vibration device used, it was decided to apply the previous techniques to studying the problem of circular flat pads with symmetrical axially centred holes of different radii.

Holes were bored into cylinders of various shape factors. The stress/strain curve for the lubricated condition was first obtained, then the cylinder was bonded to plates and its stress/strain curve again obtained. The ratio of the bonded to lubricated stresses at $\lambda = 0{\cdot}90$ was recorded. The first fact that emerged from these experiments was that the

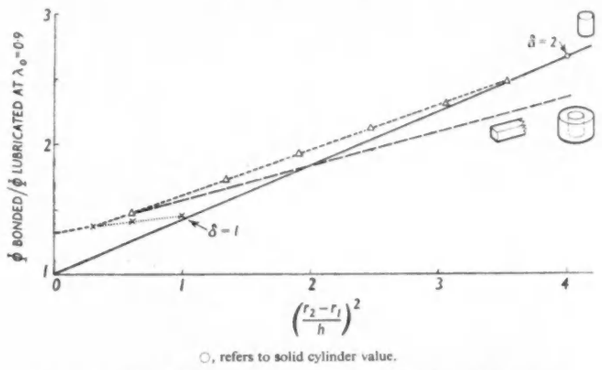
TABLE III—*Constancy of $G(\lambda - \lambda^{-2})$ for Rubbers with Differing F and S Values*

δ	F	l/b	$A + B\delta^2$ from equation (11)	30 Durometer		60 Durometer	
				Stress at $\lambda = 0{\cdot}80$ lb/in²	$G(\lambda - \lambda^{-2})$ equation (17)	Stress at $\lambda = 0{\cdot}90$ lb/in²	$G(\lambda - \lambda^{-2})$ equation (17)
2·2	1	10	5·93	300	50·5	350	59
3	1	2	7·42	385	51·9	455	61
4	1	1	9·50	466	49·2	550	58

effect of small-diameter holes was small, since it was found that :

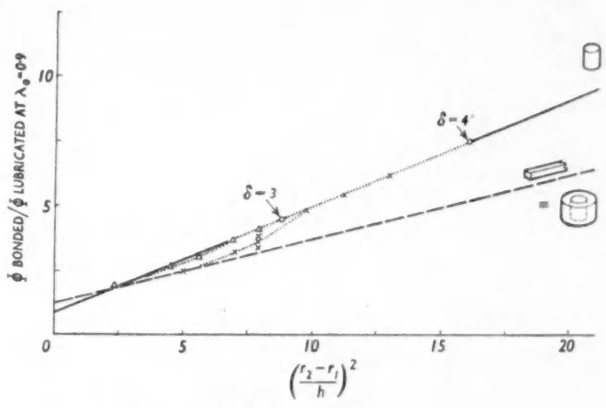
$$\Phi=(\lambda-\lambda^{-2})(1+k\delta^2) \quad . \quad . \quad . \quad (18)$$

where $\delta=(r_2-r_1)/h$, r_2 is the outside radius of the cylinder, r_1 the radius of the hole, and h the height; $k=0{\cdot}413$ as for a solid cylinder. However, as the radius r_1 became larger with respect to r_2, the value of Φ approximated to that given by a rectangle of infinite length. tends to the value of 1·33. The circles plotted on the graphs refer to the solid circular flat pad condition. The dotted curves follow the change in the ratio of Φ(bonded) to Φ(lubricated) with decreasing $(r_2-r_1)/h$ as the radius of the hole is enlarged. It is interesting to reinterpret Kimmich's data in the light of these results and this inch at $\lambda=0{\cdot}80$, is also the extrapolated zero shape factor value which coincides with the values obtained from using lubricated test pieces. It is seen that the solid square prism values (represented on the graph as circles) are also represented by equation (20). For



○, refers to solid cylinder value.

Fig. 8—Φ(bonded)/Φ(lubricated) versus $[(r_2-r_1)/h]^2$ for cylinders with concentric holes. Cylinders of initial δ=1 and 2



○, refers to solid cylinder value.
Δ, refers to cylinders of initial δ=3 and *x*, to initial δ=4.

Fig. 9—Φ(bonded)/Φ(lubricated) versus $[(r_2-r_1)/h]^2$ for cylinders with concentric holes. Cylinders of initial δ=3 and 4

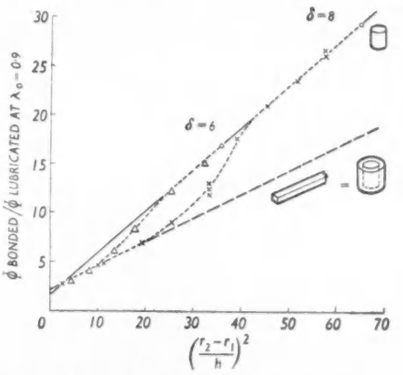
On consideration, this is a feasible hypothesis, as the bonded rubber can expand radially but not circumferentially, so that the effect of large-radius holes is to produce an infinite-length rectangle effect.

The experimental results are shown in Figs. 8, 9 and 10. The ordinates of these figures are the ratio of Φ(bonded) to Φ(lubricated) at $\lambda=0{\cdot}90$, where the two values of Φ are given respectively by the expression $(\lambda-\lambda^{-2})(A+B\delta^2)$ and $(\lambda-\lambda^{-2})$. Thus :

$$\frac{f_c\,(\text{bonded})}{f_c\,(\text{lubricated})}=(A+B\delta^2) \quad . \quad . \quad . \quad (19)$$

As r_1 approaches r_2, $(A+B\delta^2)$ tends to the value 1·33.

The values of $(A+B\delta^2)$ for the two extreme conditions, i.e. solid circular pads from equation (4) and an infinite-length rectangle



○, refers to solid cylinder value.
Δ, refers to cylinders of initial δ=6, and *x*, to initial δ=8.

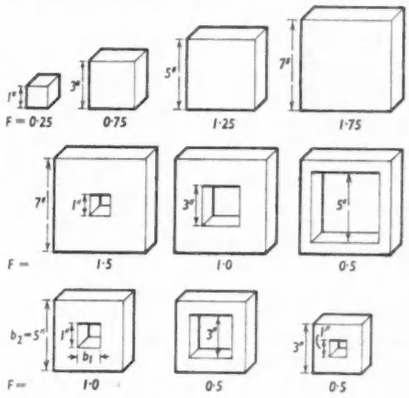
Fig. 10—Φ (bonded)/Φ (lubricated) versus $[(r_2-r_1)/h]^2$ for cylinders with concentric holes. Cylinders of initial δ=6 and 8

from equation (11), are plotted in Figs. 8, 9 and 10 as solid and dashed lines, respectively. The tendency towards these two extreme conditions is clearly seen in Figs. 9 and 10 for the higher shape factors.

From Fig. 8 it can be seen that for δ=1 and δ=2, the effect of a hole on the stress/strain relation, when r_1 is much less than r_2, is small, and $(A+B\delta^2)$ approximates to $(1+0{\cdot}413\delta^2)$ with $\delta=(r_2-r_1)/h$, solid line, but when r_1 is nearly equal to r_2, $(A+B\delta^2)$ has been done in Fig. 11, where the stress (f_c) is plotted against (load area/free area)^2 $=(b/4h)^2$ for a range of square solid pads and square pads with a central square hole in them. The slanting solid line is given by :

$$f_c=63(1+0{\cdot}525\delta^2) \quad . \quad . \quad . \quad . \quad (20)$$

where $\delta=\frac{1}{2}$ breadth/height $=b/2h$, and $G_c(\lambda-\lambda^{-2})$, which equals 63 lb per square



F=Load area of one face/load-free area.
b_1=Internal width.
b_2=External width.

Fig. 11 (*a*)—Dimensions of square prisms with central holes. (From Kimmich, 1940)

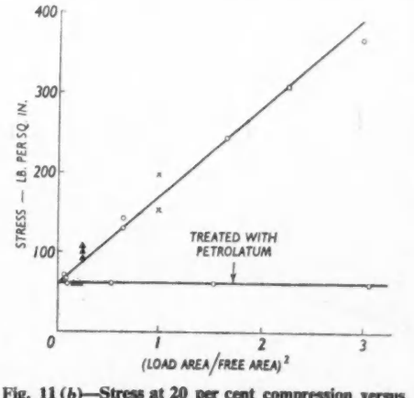


Fig. 11 (*b*)—Stress at 20 per cent compression versus (load area of one face/load-free area)^2 for square prisms of dimensions shown in Fig. 11 (*a*)

square cross-section flat pads with large holes (b_1 nearly equal to b_2), i.e. low ratio of load area of one face to free area, the experimental results (shown as triangles) are above the theoretical line for the square pad, although tending to it. For the case of a small hole, and with a high ratio of load area to free area the value (shown as a square) falls on the theoretical line. For medium-size holes, the two practical results quoted (crosses) show a bigger scatter, as expected from the experimental results on the circular pads. The results of Kimmich are too scanty to analyse in detail, but for the 20 per cent compression values it is clear that the results agree with the broad picture obtained from the experiments on circular pads, without too great an error being involved.

To summarise, the effect of a centrally placed hole is dependent on its relative size, and the value of $(A+B\delta^2)$ will vary from that quoted for a solid circular or square flat pad, in the case of an almost solid circular or square pad, to that given by equations (11), (15) and (16) for an infinite-length rectangle, for a large central hole.

Pseudo-Static Tests on Filler-Loaded Rubbers

It is expected that thixotropic breakdown or any type of structure breakdown in filler-loaded rubbers will be reflected only in the modulus G and not in Φ terms in the above equations. If this is true, then for compressions less than the previous maximum compression, G_D should be a material constant for a filled rubber vulcanisate, although its value is dependent on the previous maximum strain or dynamic amplitude.

To check this assumption bonded rubber cylinders of various mixes, but of a constant shape factor (radius/height) of unity, were compressed between the anvils of the sinusoidal strain dynamic tester, and the stress recorded thirty seconds after each increment of strain, each increment being 0·3 per cent of the specimen height. Before the test was commenced, each rubber cylinder was compressed several times to an extent greater than that to which it was subsequently compressed during the test.

Fig. 12 plots the stresses at certain compressions for the various rubbers against the

stresses at the same compressions for the unfilled (pure gum) natural rubber. It is apparent that a linear relationship exists between the stress for the unfilled and the

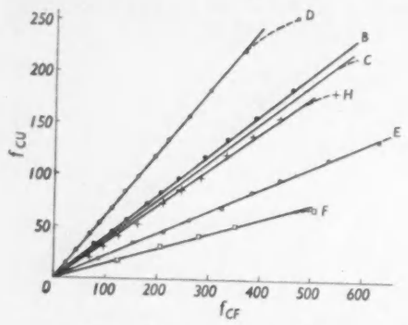


Fig. 12—Variation of f_{cu} with f_{cF}

corresponding stress for the other rubbers. As the stress/strain curve for the unfilled natural rubber can be expressed as :

$$f_{cu}=G_u\Phi \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

then

$$f_{cu}/f_{cF}=G_U/G_F \quad . \quad . \quad . \quad . \quad . \quad (22)$$

where f_{cu} and f_{cF} are the stress values at particular compressions for the unfilled and other rubbers respectively, and G_u and G_F are the corresponding material constants. The slopes of the lines can be regarded as G_u/G_F for the particular rubbers compared.

Fig. 12 shows that a divergence from linearity for some rubbers appears when the strain approaches the maximum to which the rubbers were subjected before commencing the test. This behaviour and the direction of non-linearity are expected because of the apparently rapid transition from a cyclically repeatable, but broken down, structure to a region, near the point of previous maximum compression, where structure still persists. This is in agreement with the observations by Mullins and Tobin (1954) on the behaviour of filled rubber vulcanisates in tensile tests, but the order of magnitude of the structure breakdown in compression is small compared with that which occurs at high extensions and could be ignored in most practical applications.

A linear relationship exists between f_{cu} and Φ, giving a value for G_U of 57·5 lb per square inch. Thus the corresponding values of G_F can be obtained from the slopes of the lines (Fig. 12).

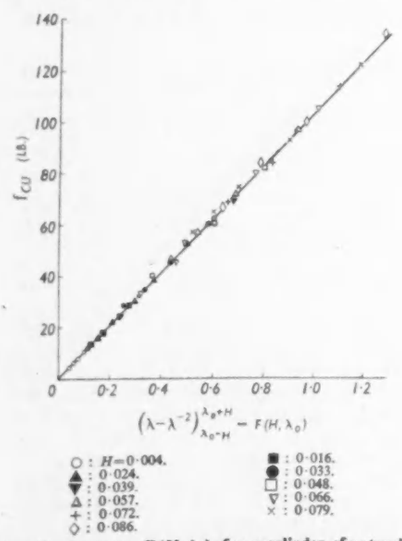


Fig. 13—f_{cu} versus $F(H, \lambda_0)$, for a cylinder of natural rubber (Mix A, Appendix I) and δ=1·0

Shape Factor in Dynamic Tests

If a sinusoidal dynamic strain of amplitude H is superimposed on a static compression to height λ_0, it can be shown that the overall dynamic stress variation f_{cu} is given by :

$$f_{cu}=G_D(\Phi_{\lambda_0-H}-\Phi_{\lambda_0+H}) \quad . \quad . \quad (23)$$

where G_D is the dynamic shear modulus at the frequency of the test. Substituting for Φ from equation (3) :

$$f_{cu}=G_D(1+k\delta^2) \, . \, F(H, \lambda_0) \quad . \quad . \quad (24)$$

where

$$F(H, \lambda_0)=[(\lambda_0-H)-(\lambda_0-H)^{-2}] -[(\lambda_0+H)-(\lambda_0+H)^{-2}] \quad . \quad (25)$$

A typical experimental graph (Fig. 13), plotting values of f_{cu} for precompressions from λ=1·0 to 0·55 and superimposed dynamic oscillations (H) from ±0·004 to ±0·086, against $F(H, \lambda_0)$, indicates that a

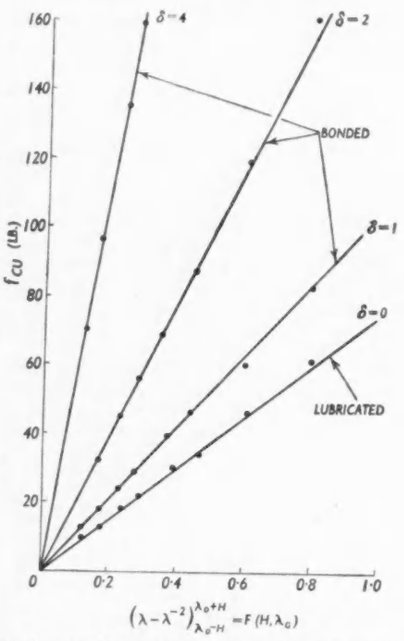


Fig. 14—f_{cu} versus $F(H, \lambda_0)$ for cylinders of natural rubber (Mix A, Appendix I): δ's=0, 1, 2 and 4

linear relationship fits the experimental points ; the slope of the line is G_D $(1+0{\cdot}413\delta^2)$ with G_D=66·3 lb per square inch, this value having been obtained from a similar set of dynamic tests using lubricated faces.

Similar results for other circular flat pads of the same material, but for a range of shape factors, are plotted against $F(H, \lambda_0)$ in Fig. 14. Again, the slopes of the linear plots are given by 66·3 $(1+0{\cdot}413\delta^2)$. The tests were carried out at a frequency of 10 c/s.

The above relationships hold for the in-phase or elastic component of the complex dynamic modulus of a pure gum natural rubber at room temperature, i.e. a rubber that behaves elastically with a very small viscoelastic component. It can be shown to hold also for the out-of-phase component ; thus, defining the complex modulus G_D^* in the usual manner :

$$G_D^*=G'_D+iG''_D$$

where

$$G'_D=\frac{\text{component of stress in phase with strain}}{\text{strain}}$$

$$G''_D=\frac{\text{component of stress 90 deg. out of phase with strain}}{\text{strain}}$$

and

$$\tan\psi=G''_D/G'_D$$

where ψ is the phase angle difference between stress and strain, it was found that tan ψ remained approximately constant over the range of compressions and dynamic amplitudes studied.

In all the above dynamic equations, G_D should now be replaced by the complex modulus $G'_D+iG''_D$; thus equation (23) becomes

$$f_{cu}=(G'_D+iG''_D)(\Phi_{\lambda_0-H}-\Phi_{\lambda_0+H}) \quad . \quad (26)$$

That the same shape factor constant should apply to the dynamic loss as well as to the dynamic modulus curves is expected, because Φ, which is a purely geometrical term, is unaffected by the rubber properties.

The only comprehensive relevant results that appear in the literature are by De Meij and Amerongen (1954) ; Fig. 15 plots E_D $(=3G_D)$ from their experimental results for a range of δ's, against $(1+2\lambda_0^{-3})$ instead

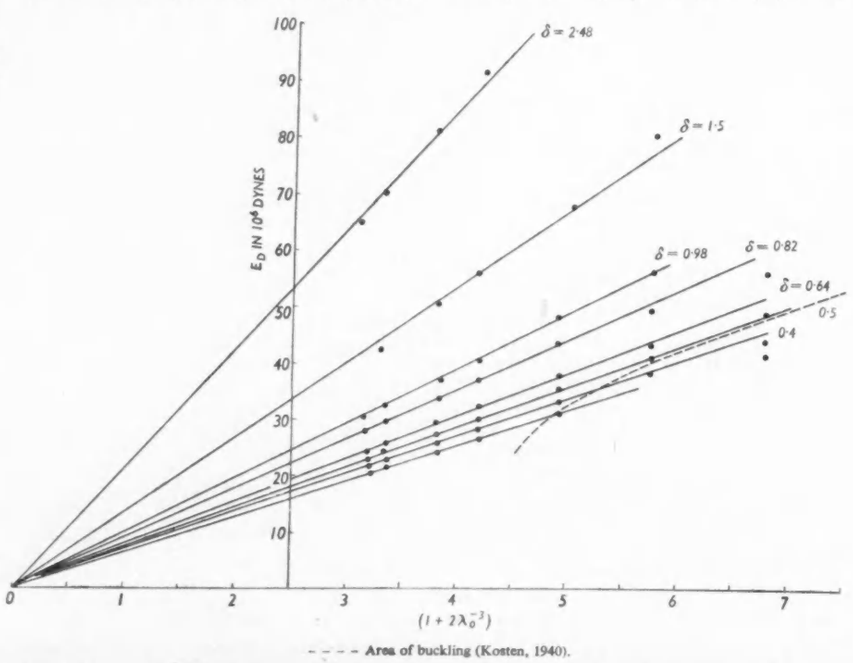


Fig. 15—E_D versus $(1+2\lambda_0^{-3})$ for cylinders of various shape factors. (Data from de Meij, *et al.* 1954)

of $F(H, \lambda_0)$ by assuming that the dynamic strain amplitude $2H$ is small. The best straight line through the experimental points and $(1+2\lambda_0^{-3})=3$ is shown. It is seen that there is fair agreement, as deviation from linearity for the low shape factors at high compressions is almost certainly due to buckling, which must occur in the regions indicated, according to the work of Kosten (1940).

If the values of E_D from the fitted curves at $\lambda_0=1\cdot0$ (i.e. zero compression and $1+2\lambda_0^{-3}=3$) are plotted E'_D against δ, Fig. 16, it is seen that these values coincide

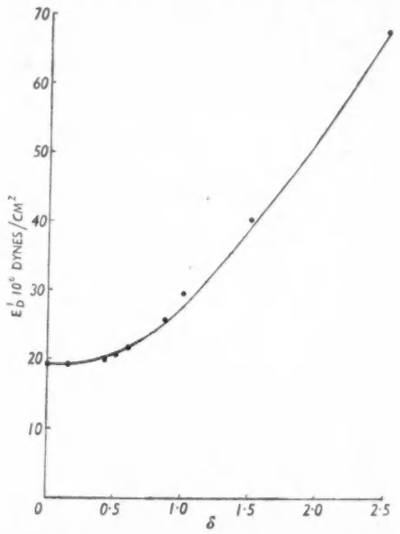


Fig. 16—E'_D versus δ. Comparison of extrapolated values of E_D at $(1+2\lambda_0^{-3})=3$ from Fig. 15 with equation (27)

reasonably well with the theoretical curve :

$$E'_D=18\cdot5(1+0\cdot413\delta^2)\times10^6 \text{ dynes per square centimetre} \quad . \quad . \quad . \quad . \quad . \quad (27)$$

where E'_D are the values of E_D at $(1+2\lambda_0^{-3})=3$ obtained from Fig. 15.

An extrapolated value of the dynamic shear modulus quoted by De Meij *et al.* (1954) was $18\cdot0\times10^6$ dynes per square centimetre, which compares well with $18\cdot5\times10^6$ dynes per square centimetre in the above equation. The dynamic modulus can thus be described over a wide shape factor and precompression range in terms of a single constant, the shear modulus. De Meij *et al.* noted that the phase angle remained constant over the shape factor and precompression ranges studied.

For rubbers containing fillers, preliminary tests indicate that the equations discussed above hold true, except that the slopes of the lines relating the dynamic stiffness with $F(H, \lambda_0)$ are amplitude-dependent. This is shown by Fig. 17 where dynamic stiffness (proportional to $(G'^2+G''^2)^{\frac{1}{2}}$) is plotted against $F(H, \lambda_0)$ as defined by equation (25), for a natural rubber mix. The four curves relate to four different dynamic amplitudes, and the values quoted by the side of the experimental points are the values of $(1-\lambda_0)$ about which the rubber is dynamically strained. It is seen that a linear relation exists between stiffness and $F(H, \lambda_0)$ for a constant dynamic strain, although the larger the dynamic strain the smaller the stiffness. As with the static tests on filled rubbers, the Φ value is the same, and it is only the G term that reflects changes due to structure, thixotropy, and the like.

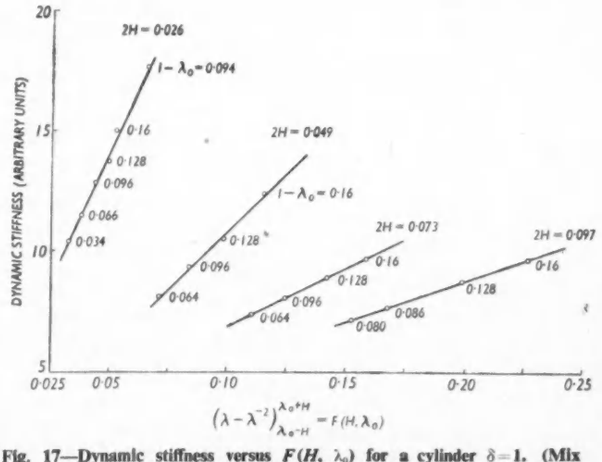


Fig. 17—Dynamic stiffness versus $F(H, \lambda_0)$ for a cylinder $\delta=1$. (Mix C, Appendix I) at four different dynamic amplitudes of strain (H) and various precompressions $(1-\lambda_0)$

Alternative Definitions of Shape Factor

In several of the earlier theories the shape factor for cylinders, for example, is the ratio of radius to height, but many other definitions of shape factor have been used, the most common being the ratio of the area of one bonded end surface to the total free area, and the limitation of the latter definition has been pointed out. Throughout this paper shape factors have been defined in terms of the linear dimensions, i.e. for cylinders $\delta=r/h$ but the general definition that appears to the writer to be most satisfactory is :

$$\text{Shape factor}=\frac{\text{cross-section area}}{(\text{height})^2}=a/h^2 \quad . \quad . \quad . \quad . \quad . \quad (28)$$

For example the term $(1+k\delta^2)$ in equation (4) applies both to squares, with $\delta=\frac{1}{2}$ width/height and $k=0\cdot525$, and to cylinders, with $\delta=$radius/height and $k=0\cdot413$. Substituting the new definition of shape factor from equation (26) in this term, then for square prisms :

$$(1+k\delta^2)=1+(0\cdot525/4)(a/h^2) \quad . \quad . \quad (29)$$

and for cylinders :

$$(1+k\delta^2)=1+(0\cdot413/\pi)(a/h^2). \quad . \quad (30)$$

Both these equations are of identical form, i.e. :

$$(1+k\delta^2)=1+0\cdot131a/h^2 \quad . \quad . \quad . \quad (31)$$

showing that the definition of shape factor as the ratio of cross-sectional area to (height)^2 is of more general application than those definitions using simple ratios of linear dimensions, but even this definition is not applicable to elongated, i.e. rectangular forms.

Discussions and Recommendations for Engineering Design

Practical problems often take two forms either (*a*) the size of the mounting is indicated and one wants to know what modulus rubber to use for a certain strain, or (*b*) one knows the modulus of the rubber and one wishes to know what size of pad to use for a certain strain. Both problems can be solved directly by the use of the above equations.

The most desirable procedure in design is to use the fundamental shear modulus as the elastic constant in the above equations ; however, in practice hardness is often used because it is easily measured by a form of indentation instrument, and the hardness can be related approximately to the shear modulus. For an ideally elastic material, and using a hardness test instrument in accordance with BS 903, 1950, the latter procedure would be satisfactory. Unfortunately, with actual rubbers, even excluding synthetics, the modulus thus determined is liable to be in error by 20 per cent, and if hardness is measured by a spring-loaded pocket gauge even greater uncertainty will arise. Nevertheless, hardness measurements may be useful in the design of mechanical applications with fairly wide tolerances in performance. For tight tolerance design the shear modulus of the rubber must be used, even though thixotropy does upset the straightforward use of a single spring constant.

To obtain the fundamental shear modulus with less ambiguity, it is quite a straightforward procedure to compress the rubber between parallel plates using a silicone lubricant and from the ratio, $f_c/(\lambda-\lambda^{-2})$, given by equation (1), obtain G. The determination of the modulus of the rubber in this manner thus permits its physical characteristics to be accurately defined, besides which, the modulus determined in this way gives a better indication of the properties of the rubber specimen throughout its entire volume, whereas rubber indentation tests may only indicate the hardness on or near the surface.

When the loading faces of a rubber are parallel and are adequately lubricated the stress/strain relationship is given by equation (1) which was derived from the kinetic theory of rubber-like elasticity for a pure homogeneous compression. This relationship is independent of the shape of the rubber.

The essential equations that have been derived in this part of the report for flat pads of various cross-sectional shapes loaded in compression are :

In general $f_c=G\Phi$ and for the pseudo-static stress/strain curves we have $f_c=G(\lambda-\lambda^{-2})(A+B\delta^2)$.

For dynamic straining $f_c=G_D\ F(H, \lambda_0)(A+B\delta^2)$ where $F(H, \lambda_0)$ is defined by equation (25). The following values of A and B and definitions of δ in these equations refer to specific applications.

	A	B	δ
Lubricated pads of any cross-sectional shape	1	0	—
Bonded square flat pads ...	1	0·525	$\frac{1}{2}(b/h)$
Bonded circular flat pads ...	1	0·413	r/h
Bonded rectangular flat pads	1·33 $(1+0\cdot5b/l)/(1+b/l)$	$1/(1+b/l)$	$\frac{1}{2}b/h$
Bonded circular flat pads with central hole $r_2\gg r_1$	1	0·413	$\frac{r_2-r_1}{h}$
Bonded circular flat pads with central hole $r_2\simeq r_1$	1·33	1·0	$\frac{r_2-r_1}{h}$

(To be concluded)

PRACTICAL TECHNIQUES IN THE USE OF MASTIC ASPHALTE.—Many clerks of works, and similar officers, do not have sufficient knowledge to supervise efficiently techniques in the use of asphalt. So that they may be able easily to check that the proper principles are applied, the Natural Asphalte Mine-Owners and Manufacturers Council has issued a pocket book " Mastic Asphalte and its Application." This publication gives in the form of codes of good practice, the main points to be observed to ensure that complete waterproofing is obtained in basement work and in roofing ; and that the best technique is adopted in laying mastic asphalte floors. Copies of the booklet are available from the Council at 94–98, Petty France, Westminster, London, S.W.1.

Stroboflash-Coincident Unit for Engine Indicating

By R. S. BENSON, M.Sc.(Eng.), A.M.I.Mech.E.*

A stroboflash-coincident unit which was originally developed for setting the release pressure of a special two-stroke cycle model and can be readily applied to engine indicating is described. The unit was designed to operate on two channels, either separately or together. On one channel a make and break circuit operates the stroboflash and on the other channel a search coil circuit fires the lamp. When operating as a coincident unit the controls are set so that the stroboflash only fires with the simultaneous arrival of signals from the separate channels. For engine indicating the search coil circuit is used for crank angle selection and the make and break channel for pressure indicating. A simple system for this purpose is described. The application of the instrument to determine the friction error of a Farnboro light spring indicator is discussed and test results are given.

THE principle of stroboscopic engine indicating is well known, examples of the technique are the Farnboro indicator,[1] the Sunbury point by point indicator[2] and the straight stroboscope lamp.[3] In all three methods an average indicator diagram is taken over a number of cycles. The principle of operation is the balancing of a known pressure by the cylinder pressure which causes the production of an electric signal. In the Farnboro indicator a large permanent diagram is obtained over some 200 or so cycles, thus the time taken is relatively short. The Sunbury method involves the use of a cathode ray oscillograph and the time for indicating is longer than with the Farnboro. The third method requires a standard stroboscope lamp which is operated from the pressure pick-up, the lamp is situated opposite a marked timing disc and the point of balance may be obtained by visual observation of the disc. Whilst both the Farnboro and Sunbury indicators involve the use of expensive and bulky electronic-mechanical equipment, the stroboscope lamp is usually a small compact piece of equipment. Its major disadvantage is that for rapidly fluctuating pressures involving several rises and falls in pressure per cycle the continuous flashing at each balance point would render it difficult to observe the correct crank angle. In this article an instrument is described which operates on the stroboscope lamp principle but enables the pressure at each point in the engine cycle to be determined, whether the pressure is fluctuating during an engine cycle or not, and further it is possible to distinguish between a rising and falling pressure. The instrument may, therefore, be used for " light spring " indicating in inlet or exhaust manifolds.

Originally the instrument was developed to enable the pressure at a fixed point in a model simulating an engine cycle to be controlled by adjusting the engine conditions. In addition to this function it was also proposed to use the unit to ascertain the friction errors when indicating at low pressures with the Farnboro indicator. Since the B.S.R.A. version of the Farnboro[1, 4] was used with a thyratron relay it was thought desirable to reduce possible differences between the new unit and the Farnboro relay unit, thus the same or similar valves were used, and as far as possible the same type of circuit ; the same power pack was used at slightly different voltage conditions. The pressure pick-up was identical to the type described by Roach and Hempson,[1, 4] but the unit could also operate with the Sunbury calibrator.[2]

Description of Instrument

The electronic circuit is shown in Fig. 1, photographs of the unit are shown in Fig. 2 (*a*) and (*b*).

The pressure pick-up acts as a " make " and " break " earthing switch which produces a rectangular pulse, this pulse is differentiated and fed into the double triode (12AU7) phase splitting circuit which provides at one anode an antiphase signal of negative going pulse for " make " and positive going pulse for " break " and at the other anode a phase signal of positive going pulse for " make " and negative going pulse for " break." The output from the degree marker search coil is fed via a potentiometer p_1 to a single pentode (6F12) amplifier. The polarity of the search coil is arranged to give a negative going leading edge on the output pulse. The anode of the pentode (6F12) is capacity coupled together with one of the anodes of 12AU7 through switch s_1 to the triggering electrode of the stroboflash (NSP1) which is also supplied with a variable bias control p_2. The stroboflash fires when the potential difference between the triggering electrodes is sufficient for the ionisation or " striking " of the tube. One electrode is fixed at about 50 V.D.C. positive and the striking potential is produced by the negative going pulses and the bias. Since both the amplitude of the degree marker pulse and bias are variable it is possible to arrange for the tube to fire independently either with the pressure pick-up (" make " or " break ") or the degree marker, or as a coincident unit when both negative going pulses are superimposed on the bias of NSP1. The switch s_1 isolates the " make " and " break " operations. In practice with slight stray capacitance it is possible to control the amplitude of the differentiated signal from the pressure pick-up. For this purpose a potentiometer p_3 is placed at the input to 12AU7 and acts as a pressure pick-up amplitude control; this is adjusted so that NSP1 ceases to fire when operating on the pick-up alone with the bias p_2 at mid position. The signal into and out of 12AU7 is extremely sharp and the striking time for NSP1 does not appear to be measurably affected by the bias control p_2.

The signal from the search coil is of distorted sinusoidal form[2] : in order to obtain accurate timing it is necessary to operate with the peak of the signal only. This is carried out by adjusting the amplitude control p_1 in the manner outlined later. As will be seen from the photographs of the unit there are in addition to the usual on-off switches for the search coil and pressure pick-up and the " make " and " break " isolating switch, only three controls. These are the bias control p_2 (coarse and fine), the degree marker amplitude control p_1, and the pressure pick-up amplitude control p_3.

For engine indicating or simple coincident work the auxiliary equipment consists of nitrogen or other form of compressed gas supply, pressure gauges, pressure pick-up, and degree marker unit. The latter consists of either a peg on a flywheel with a search coil situated opposite the peg at some known crank angle reference point, or an insulated disc with a steel insert in place of the peg on the flywheel.

To operate as a stroboscope from the pressure pick-up alone p_2 and p_3 are adjusted until the tube fires at pressure balance. By locating the lamp opposite a marked disc driven by the crankshaft the pressure at each point in the cycle can be determined in the usual manner. When operating as a coincident unit p_2 is set at mid position and amplitude controls p_1 and p_3 are adjusted so that neither the search coil nor the pressure pick-up fires the lamp alone. When the lamp flashes the signals are coincident and for the known reference crank angle the pressure is determined.

In the following section a number of applications of the unit are described.

* The University of Liverpool.

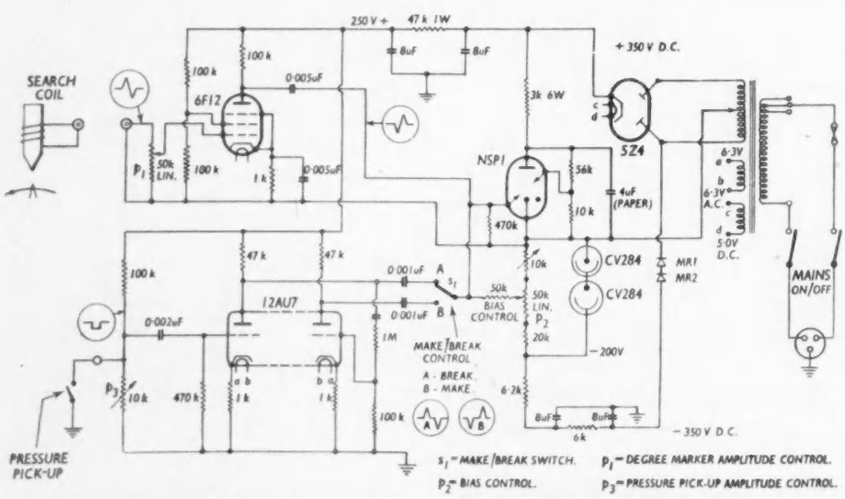


Fig. 1—Diagrammatic arrangement of stroboflash-coincident unit circuit

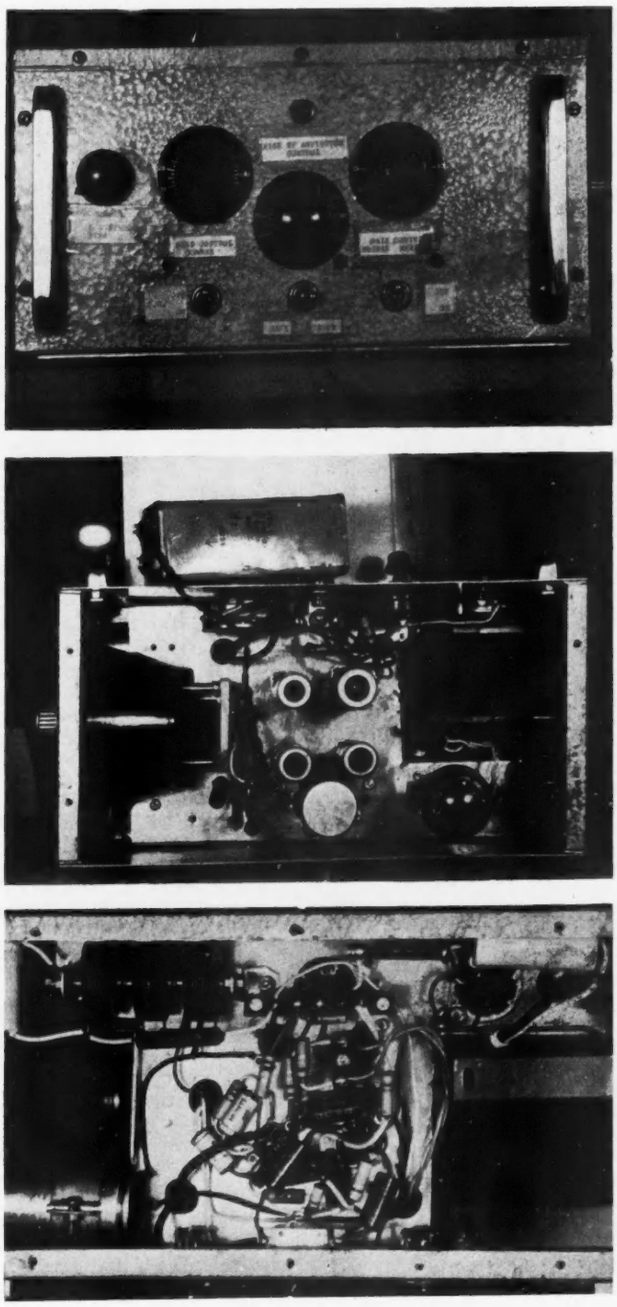
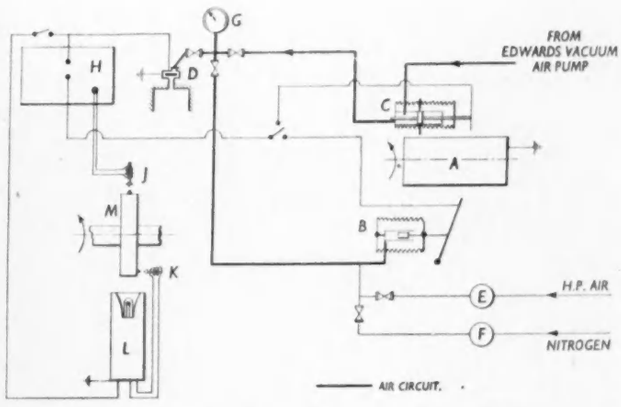


Fig. 2—Stroboflash-coincident unit (top) with cover removed (centre) and base removed (bottom)



A—Farnboro drum.
B—Farnboro h.p. cylinder unit.
C—Farnboro ultra l.p. cylinder unit.
D—Pressure pick-up.
E—H.p. air regulator valve.
F—Nitrogen regulator valve.
G—Calibrating pressure gauge.
H—Electronic relay.
J and *K*—Degree marker search coils.
L—Stroboflash-coincident unit.
M—Flywheel.

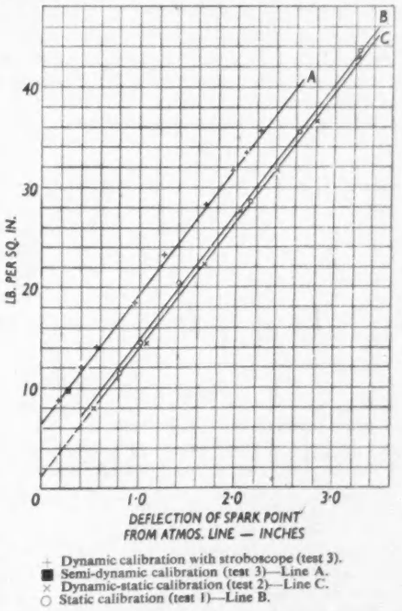
Fig. 3—Layout of Farnboro calibrating unit

Applications

1. *Control Unit for Indicating Pressure at Fixed Point in Cycle.*—As referred to above, the unit was originally developed as a control unit for setting the release pressure of the model two-stroke cycle engine described in a previous article.[5] A diagrammatic arrangement of the scheme is shown in Fig. 3. A peg on the flywheel passed a search coil which was adjusted so that a signal was received when the ports opened. By applying a known pressure at the pressure pick-up corresponding to the desired release pressure the supply pressure to the model was adjusted until the stroboflash fired.

2. *Calibrator for Farnboro Light Spring Diagrams.*—It is well known that there might be considerable friction errors[4] in the light spring diagrams taken with the Farnboro indicator. Recently[4] a new ultra light spring unit (U.L.S.) has been developed for −10 lb per square inch to +10 lb per square inch in which the friction error is negligible. For pressures within the range 0—80 lb per square inch the original light spring unit (L.S.) can be used up to approximately 25 lb per square inch and for higher pressures up to 80 lb per square inch a new medium spring (M.S.) is available. With both these spring assemblies there could be considerable error in the location of the atmospheric line due to friction in the piston unit and link gear. The error became significant in low-pressure studies in the cylinder. In addition to the atmospheric line error there were also some errors due to friction when the link gear was moving. In order to ascertain the magnitude of these errors a series of tests was carried out with the 0—80 lb per square inch spring assembly in conjunction with the coincident unit. The test arrangement was the same as in Fig. 3 with the pressure pick-up *in situ*. In the first test, test 1, the usual static calibration was carried out with the model and the Farnboro stationary. Test 2 was similar to test 1 except that the model[5] and Farnboro were run at 700 r.p.m., this speed corresponded to a critical speed of the machine, thus producing violent vibrations and hence reducing friction in the piston assembly. Test 3 was in two parts, in the first part a Farnboro indicator diagram was taken with the model operating " on load." The release pressure was set with the coincident unit and the pressure noted ; at the end of the spark point travel a 70 lb per square inch calibration line was sparked on to the diagram. In addition to the normal diagram, an ultra light spring diagram was also taken. In the second part of the test a point-by-point diagram was taken with the coincident unit acting as a straight stroboscope operated by the pressure pick-up alone; for this purpose the lamp was placed opposite the flywheel which was marked in degrees.

The results of this investigation are shown in Fig. 4 and Fig. 5. It will be seen that all the results show reasonable linearity between pressure and spark point travel, although there is a tendency to scatter in tests 1 and 2, i.e. in the static and static-dynamic tests. By using the maximum pressure from the U.L.S. diagram as the lower calibration pressure and the pressure at port opening as an upper calibration pressure a dynamic calibration can be obtained assuming linearity between pressure and spark point travel; alternatively in place of the pressure at port opening the maximum calibration pressure obtained by firing a line of known pressure on the diagram can be used as the upper point. In this case the calibration is semi-dynamic as there would be a slight friction error when the spark point stops. Line *A* was obtained by the latter method (Fig. 4). It will be seen that this gives very good agreement with the point-by-point results. It will be observed



+ Dynamic calibration with stroboscope (test 3).
■ Semi-dynamic calibration (test 3)—Line A.
× Dynamic-static calibration (test 2)—Line C.
○ Static calibration (test 1)—Line B.

Fig. 4—Farnboro calibrations of 0–80 lb per square inch spring

that there was considerable friction at the starting point in addition to the normal atmospheric line error.

The friction error will vary with the pressure range, speed of operation of engine, speed in taking diagram. Fig. 6 shows a histogram of some thirty-nine tests showing the dynamic and semi-dynamic calibrations as obtained by the methods outlined above. The slight displacement in the distribution of the two rates is probably due to the factors discussed above. In order to reduce the difference between the two rates to within 0·2 lb per square inch per inch it is necessary to control the speed of the spark point,which should move as slowly as possible and at a constant rate (an average time of about twenty-five to thirty seconds). In the test rig shown in Fig. 3 this was carried out by fitting a 0—100 lb per square inch variable reducing valve with a large handwheel which could be rotated at a constant rate. With these precautions and using a dynamic or semi-dynamic calibration an accuracy of the

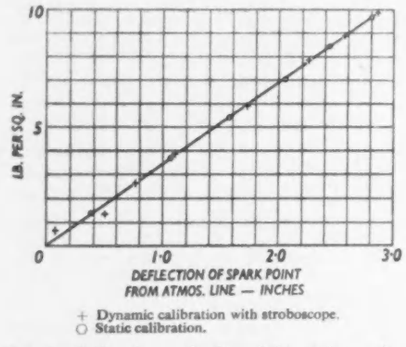


Fig. 5—Calibrations of ultra light spring unit—−10lb to +10 lb per square inch

order of less than 2 per cent can be obtained from 10 lb to 80 lb per square inch. For lower pressures the new ultra light spring unit can be used with exceptionally high accuracy.

3. *Point-by-Point Indicator*.—If, instead of fixing the search coil so that a signal were produced at one fixed point in the engine cycle, the search coil were mounted on a disc or plate which could be free to move, then each point in the engine cycle could be isolated in turn. For this purpose the stroboflash-coincident unit would operate on both channels. Since both rising and falling pressures are required it is necessary during the manufacture of the electronic unit to make the output at *A* and *B* (Fig. 1) equal, this will necessarily depend on the valve (12AU7) characteristics and appropriate re-

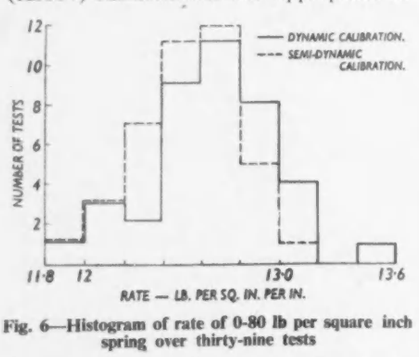


Fig. 6—Histogram of rate of 0-80 lb per square inch spring over thirty-nine tests

sistances will have to be selected to obtain the required balance. To test the application of the unit for point-by-point indicating a test rig was set up from material available in the laboratory. An old version of the Sunbury time sweep unit was modified, the cam assembly was replaced by a hardboard

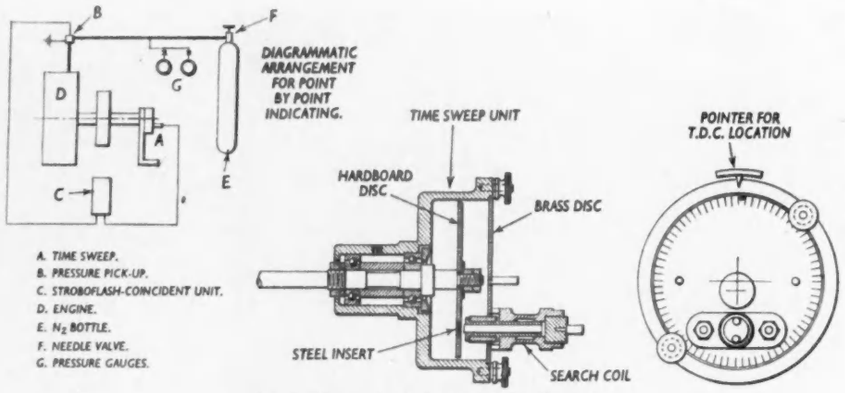


Fig. 7—Set-up for point-by-point indicating

disc with a thin steel insert fitted radially. The end plate was replaced by a simple brass plate whose periphery was marked in crank angle degrees, and into which was mounted the search coil. The clearance between the pole of the search coil and the rotating disc was 0·020in. The time sweep unit was coupled to the engine crankshaft extension. The complete layout is shown in Fig. 7.

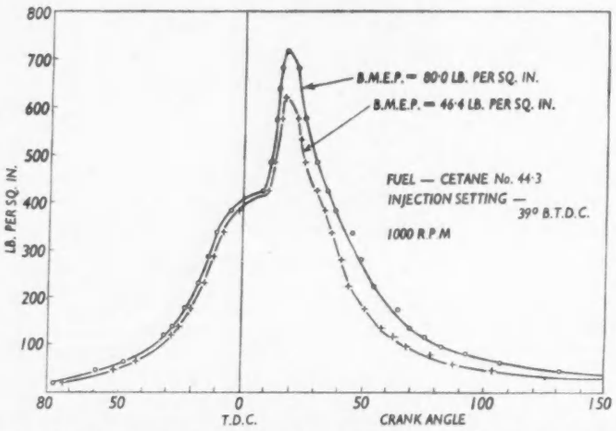


Fig. 8—Typical diagrams—National Gas instantly-convertible diesel-gas engine

It is necessary in engine indicating to ensure that the top dead centre is accurately located, a dynamic method was, therefore, used. The engine flywheel was already marked for valve timing settings, the stroboflash unit was, therefore, mounted near the timing pointer and the top dead centre mark on the flywheel was painted white. With the engine running on load and conditions stabilised the unit was switched on to the pressure pick-up only. The nitrogen pressure was increased until the pressure at T.D.C. was determined by visual alignment of the mark on the flywheel and the pointer. With the pressure maintained constant the amplitude control p_3 was turned back until the stroboflash ceased to fire. The search coil circuit was then switched on and the time sweep unit adjusted by rotation of the end plate until the stroboflash fired again, this time in coincidence with the pressure pick-up. Potentiometer p_1 was then adjusted until a sharp response from the lamp was obtained when the search coil was moved from either side through T.D.C. To check whether the peak of the search coil signal only was being used visual observations of the mark on the flywheel and the pointer was made. These appeared in phase only when the lamp flashed.

To take an indicator diagram a series of known pressures were set at the pick-up and the time sweep adjusted until the stroboflash fired, the crank angle at each balance point being noted. A rising or falling pressure could be determined by the position of the make and break switch. Typical diagrams are shown in Fig. 8. These were taken in a small National Gas instantly convertible diesel-gas engine operating on oil.

4. *Other Applications*.—The make and break type of pressure pick-up can be replaced by the Sunbury calibrator[2] for engine indicating by using a similar or the same channel as the search coil circuit. Other applications of the unit are fuel valve timing, ignition timing, fuel pressure measurement. It may be necessary in certain of these applications to modify the circuit by adding another amplifying stage and differentiating circuit to obtain a sharp signal.

The timing unit may be calibrated directly in midordinates thus enabling a fairly rapid computation of mean effective pressure to be obtained. The method could also be readily applied to free piston units without a rotating crankshaft.

Acknowledgments

The instrument and apparatus discussed in this article were developed and tested in the Walker and Harrison-Hughes Engineering Laboratories of the University of Liverpool. The author wishes to acknowledge with thanks the help and facilities given by Professor W. J. Kearton, Harrison Professor of Mechanical Engineering.

The author wishes to acknowledge with thanks the help and advice given by Mr. E. Duffy, A.M.Inst.E., who constructed the electronic equipment. The author also wishes to acknowledge the help and advice given by Mr. W. Miller, Superintendent of the laboratories, and his staff, in particular the assistance given by Mr. E. Hobson in the experiments and tests referred to in the article.

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Crawler Tractors

British tractor production includes an increasing number of wheeled machines for agricultural work and for a variety of tasks in industry. But it includes also many tracklaying or crawler tractors of medium and high horsepower rating to meet the requirements of public works contracting, land reclamation, forestry and "pioneer" work in all parts of the world. This article is concerned with two recent additions to British crawler tractors, the Vickers "Vigor" and the Albion Cuthbertson "Water Buffalo."

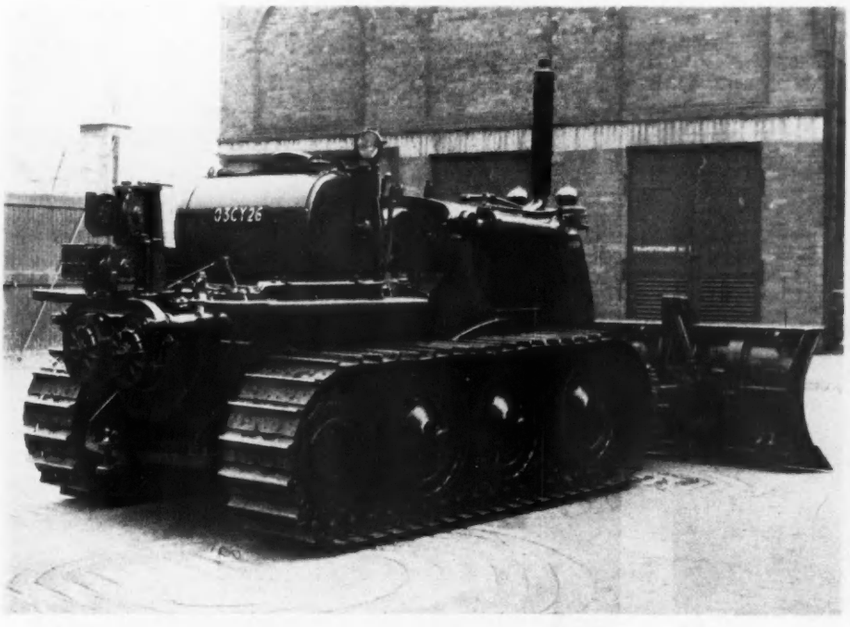
LAST week, we visited the Scotswood Works, at Newcastle upon Tyne, where Vickers-Armstrongs (Tractors), Ltd., builds the "Vigor" and "Vikon" tractors. During this visit, the company announced the receipt of a contract from the Ministry of Supply for sixty "Vigor" tractors, with their associated equipment, which will be used by the Royal Engineers. Some of these tractors are already at work in difficult terrain overseas, as, for example, in the Malayan jungle, where the Royal Engineers are building a 64-mile length of road. Our title illustration shows a tractor fitted with overhead cable dozing equipment being used on a bank cutting job for this road.

The Vickers "Vigor" is powered by a Rolls-Royce six-cylinder, supercharged diesel engine, with dry-sump lubrication, which develops 180 belt horsepower at a governed speed of 1800 r.p.m. The crankcase and cylinder block are integral and are made of cast iron. The wet-surface cylinder liners are removable and the twin cast iron cylinder heads serve three cylinders each; the fuel injectors are located in the tops of the cylinder heads. The tractor's main frame is built of §in steel plate; it carries the front suspension unit, the engine and cooling system and completely encloses the dry sump and oil reservoir. Machined faces are provided for the attachment of dozer equipment and the drawbar is anchored to a pivot bracket on the underside of the main frame.

The suspension system has been designed to enable the full bottom-run of the tracks to be kept in constant contact with the ground. The system consists of eight large-diameter wheels which are linked in pairs, each pair oscillating on an individual pivot. The two front pivots are interconnected through a cross beam oscillating transversely beneath the main frame, while the two rear pivots have their centres on the reduction gear output shafts. By this arrangement, it is claimed, the weight of the hull is distributed evenly between the middle of the cross beam and the two rear track wheel and sprocket assemblies, thereby eliminating stresses. Excessive track tension is automatically countered by buffers which are attached to the track adjusters and act independently on the front wheels. The rear track wheel and sprocket assemblies incorporate the final drives. The gear train of each drive is arranged so that the reacting torque, which tends to turn the whole housing round its central pivot, is exactly equal and opposite to the torque reaction exerted by the track on the sprocket. The rear suspension units are thus free to mould the tracks to the surface of the ground. Each wheel, it should be added, is insulated by two rubber rings separating the rim from the hub. The object of these mountings, which allow a deflection of up to $\frac{5}{16}$in under load, is, of course, to damp out the high-frequency vibrations which would otherwise be transmitted through the body of the tractor. In the sprocket wheels there are four rubber rings to separate the outer wheel from the hub.

The length of the tracks on the ground is 8ft 8in, the area of ground contact (with standard 22in wide track shoes) being 4756 square inches, and the ground bearing pressure 7·4 lb per square inch. Each pair of links in the track assembly is pressed on to a sleeve and interlocked with the preceding pair of links by a pin which is passed through the sleeve and pressed into the preceding link bosses. Rubber seals, situated at each end of the sleeves, imprison the lubricating oil which is forced round the pins during the initial assembly of the tracks. The tread-plates are bolted to the links. Two removable master pins are provided in each track so that, should it be necessary to take a track off the machine, one master pin is always accessible.

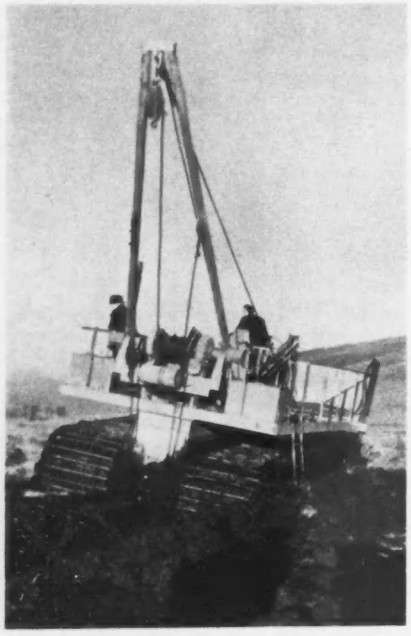
The tractor's six-speed gearbox is in principle two gearboxes built into one. The upper layer provides high, low and reverse-gear ratios, and the lower set gives three relative speeds for each particular ratio. This combination permits six forward speeds between 2·18 and 9·73 m.p.h. and two reverse speeds. In the full-torque transmission unit, which is the tractor's standard equipment, each final drive comprises two large gear wheels, of identical size, which mesh with an idler gear. These gears maintain a constant balance between the torque on the drive and that exerted by the track on the sprocket. The steering clutches convey the drive through a series of toothed friction discs; when a clutch is released, its discs separate instantly and, when engaged, the pressure of thirty springs ensures immediate take-up. Clutch-release is actuated by an automatic, hydraulic servo system controlled by the steering levers; a seven-cylinder pump, driven from the gearbox, gives constant oil pressure throughout the system. The steering brakes are operated independently by the steering levers, there being also an



"Vigor" tractor powered by six-cylinder Rolls-Royce engine, which develops 180 belt horsepower. This tractor is fitted with a hydraulic dozer blade and a rear control unit

over-riding foot pedal which allows both brakes to be applied simultaneously.

As an alternative to the six-speed gearbox, a Rolls-Royce Twin Disc torque converter and a Vickers three-speed gearbox can be installed in the " Vigor " tractor. This unit provides an infinitely-variable torque-ratio transmission train. The gearbox provides three forward speeds of 4·66, 6·4 and 8·8 m.p.h., and a reverse speed of



The latest " Water Buffalo " is powered by a 150 b.h.p. Leyland engine. This tractor has been designed to pull barges or " slipes " (with payloads of up to 28 tons) through swamps

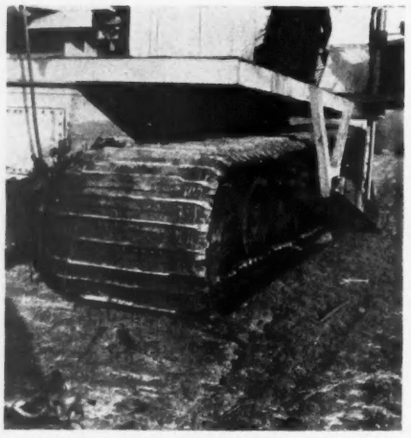
5·15 m.p.h. The hydraulic torque converter comprises three principal parts, namely, a housing which is integral with the engine-clutch housing, an impeller and a turbine wheel. The impeller, which is driven by the engine through a pedal-operated, single-disc clutch, gives a circular motion to the fluid in the converter, while the fluid, in turn, rotates the turbine wheel. The turbine wheel is connected to the gearbox by a coupling shaft.

Several items of associated equipment for operation by the " Vigor " tractor are produced by Vickers-Armstrongs (Tractors), Ltd. They include scrapers, dozers, rippers, winches and compaction rollers. An accompanying illustration shows the tractor fitted with a dozer and equipped with a rear control unit. This assembly comprises twin spur-gear-driven drums, each having a capacity of 220ft by $\frac{1}{2}$in cable. The drums are controlled by a combined clutch and brake mechanism, the brakes being automatically applied when the clutches are released. The drive is taken from the rear end of the gearbox.

The " Water Buffalo "

For work in swamps and similar terrain where conventional crawler tractors could not be expected to operate successfully, the " Water Buffalo " was designed a few years ago by James A. Cuthbertson, Ltd., Biggar, Scotland, in conjunction with Albion Motors, Ltd. Reclamation and drainage work on Scottish hill lands which was undertaken by the designer, Mr. J. A. Cuthbertson, emphasised the need for a machine capable of traversing swamps and at the same time hauling heavy loads of equipment. Two important design factors of the " Water Buffalo " are its flexible rubber track and its watertight steel hull which keeps the engine, transmission and steering dry even in a 4ft depth of water and, additionally, prevents the tractor from sinking when stationary. The track fitted to the standard " Water Buffalo " is 36in wide ; it gives exceptional adhesion by "enveloping" the ground surface instead of riding the high spots, the ground pressure obtained being about $2\frac{1}{4}$ lb per square inch. One of our illustrations shows a standard "Water Buffalo" (The Engineer, July 13, 1956) which is fitted with a four-cylinder, 75 b.h.p. Albion diesel engine.

Recently, we were present at the trials of the latest " Water Buffalo." This is a much bigger machine which has been designed for the Shell-B.P. Petroleum Development Company of Nigeria, Ltd. The tractor is required mainly for the transport of heavy oil drilling equipment and materials into the heart of the Niger Delta swamp lands. The new " Water Buffalo," which is illustrated herewith, is just over 23ft long and weighs about 24 tons. It is powered by a six-cylinder Leyland engine, which develops 150 b.h.p. at 2000 r.p.m., the maximum torque being 450 lb-ft at 1100 r.p.m. The engine is fitted



The track of the new " Water Buffalo " is 48in wide, exerting a ground pressure of not more than 2 lb per square inch

with a five-speed " Pneumo-cyclic " gearbox (see The Engineer, November 20, 1953) and centrifugal clutch.

The watertight hull of the new tractor is built of sheet steel, there being removable covers for inspection and servicing of the engine. An amphibian body can be fitted to the hull to enable the tractor to float in free water. The tractor is supported on two large unsprung idler wheels at the rear and ten idler wheels (five on each side) on sprung crank axle assemblies. These axle assemblies are able to move vertically under the weight of the tractor on the tracks, and thus keep the tracks in contact with the ground. The forward moving part of the track, between

A standard "Water Buffalo" for work on soft and marsh lands. The power unit of this tractor is a 75 b.h.p. Albion diesel engine

The new " Water Buffalo " hauling a " slipe " through marsh land

the rear idler wheel and the front driving sprocket, is supported by four small idler wheels. Power from the engine is taken through the gearbox to a cardan shaft which transmits it to a distribution gearbox, where the drive divides into two parts. The power is then controlled by two independently operated clutch and brake mechanisms, each driving one track only, through a worm drive to a spur gear final drive.

The most important part of the " Water Buffalo " is the 48in wide tracks which, like the tracks of the smaller machine, have no conventional link pins and bushes. The track links are joined by flexible rubber pads which are moulded round a series of wire linked ferrules to take the track bolts. The drive sprocket is at the front so that the track top is in tension and the bottom run is therefore free to mould itself closely to the ground undulations. An accompanying illustration shows the track arrangement. For these 48in wide tracks, it is claimed that they have a tread " far lighter than a man," exerting a ground pressure of only about 2 lb per square inch.

A hydraulically operated dozer blade has been fitted to the tractor to enable it to make its way through virgin country, forest land and swamps. But, of course, this dozing equipment is for making preliminary roads in normally inaccessible areas ; the machine is not primarily designed as an earth mover to compete with conventional crawler tractors.

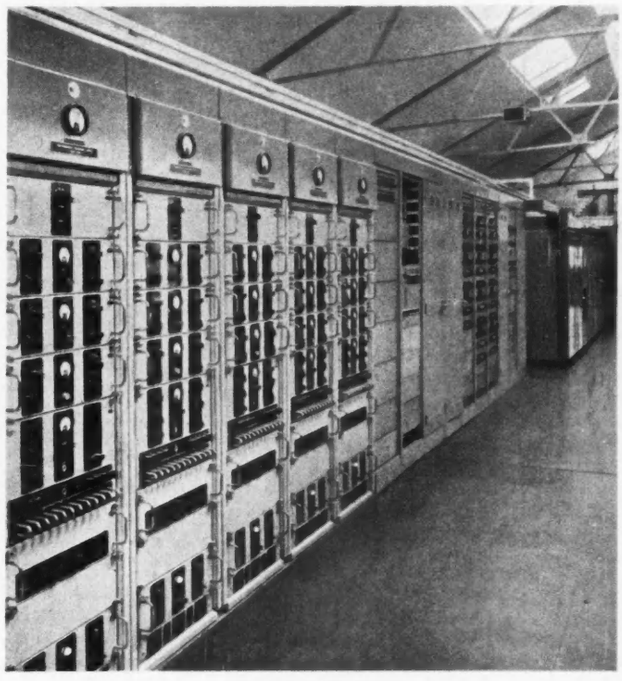
To enable the " Water Buffalo " to perform various operations required in oil exploration surveys, as well as the erection and transport of drilling rigs, an oil field winch and gin pole assembly have been fitted at the rear. With this winch and gin pole, a lifting capacity of up to 10 tons can be obtained. The winch is specially geared to enable the lifting and transport of drilling rig components, and has a sufficiently low operating speed to assist in the erection of these components when being used as a crane. Another interesting point about the new tractor is that it can be fitted with a capstan winch, designed to run at track speed in all gears. This means that in land conditions, where the surface of the land is unable to transmit the drawbar pull exerted by the tractor, the winch can be used as an additional means to gain the necessary tractive effort. By a special arrangement on the winch, the tractor can run on a permanent cable, when, for example, a section of free water is encountered, where the tracks of the tractor cannot assist in propulsion. Furthermore, for exceptionally high drawbar pulls in soft conditions, the winch and tracks are operated together to pull any implements or loads. In order that the machine can be handled satisfactorily by semi-skilled labour, all the controls, including steering, braking and operating the capstan winch and gin pole winch are by compressed air.

The new " Water Buffalo " is being shipped to Nigeria with two amphibious trailers or " slipes," one having a payload of 28 tons and the other of 10 tons. It has been found that the most satisfactory method of transporting loads by the " Water Buffalo " is by these slipes, which are pulled behind the machine. The slipes can be fully amphibian when loaded, so that the loads can be transported by water as well as land, and all of them are fitted with large aircraft wheels, which protrude approximately 9in below the base. When on hard ground, the slipe runs on wheels, and when on soft ground the wheels penetrate 9in into the surface so that the base of the slipe takes up and spreads the load to give a very low ground pressure.

New Radio Transmitters at Ongar

SEVEN new high-frequency transmitters were brought into operation at Ongar Radio Station, North Weald, Essex, on February 19. This is one of the principal transmitting stations in the Post Office overseas radio-telegraph services, handling public telegraph, international Telex, picture and leased telegraph traffic to most parts of the world by short-wave beam radio.

The new transmitters were inaugurated on behalf of the Postmaster-General by Lord Chesham, who said that the principal reason for the world's telegraph services was the public message service. Over 500 million words in about 25,000,000 messages were handled each year by the London station at Electra House. One-third of that very large volume of traffic originated and finished outside the United Kingdom, so that the London office could be considered as the hub of the world's telegraph communications. The International Telex Exchange was now handling more than 300,000 calls a month, and forty-three long-distance radio circuits were on lease to business concerns for their own use.



Drive units (foreground) and new H.F. transmitters in "D" station at Ongar

He foresaw that the radio service would be required for many years to supplement cable facilities, for not only would growing communications requirements have to be met in the period while cables were being provided, but it was also a fact that the provision of communications by one method invariably seemed to lead to a demand for them in general. Lord Chesham then switched on the new transmitters by operating a remote control push-button and handed to an operator a message of greeting addressed to H.R.H. the Duke of Edinburgh on board H.M.Y. " Britannia," which was transmitted via Singapore and Kranji.

The seven transmitters now brought into use have been designed and manufactured by Standard Telephones and Cables, Ltd., to Post Office specification. They operate on any of six frequencies in the band from 4 to 27·5 Mc/s (75m to 10·9m) and have a peak output power of 30kW. Starting, frequency-changing and shutting down are normally controlled remotely from the " C " station at Ongar, about half a mile from the " D " station in which the new equipment is installed, and remote monitoring is also provided. Types of transmission in use at Ongar include telex, teleprinter and cable code, automatic Morse and picture transmission ; telephony could be transmitted if required. Frequency-shift keying with a shift of 400 or 800 c/s is employed for telegraphy, and the keying and single-sideband operation can be monitored on a spectrum analyser in the control room.

Traffic is received from Electra House by landline in the form of audio-frequency tones. These are converted in the receiving unit in the control room into positive and negative d.c. voltages for keying the transmitter drive units. From these a keyed radio-frequency of 3·1 Mc/s is fed into the appropriate stage of the first section of the S.T. and C. Type DS13D transmitter.

The first transmitter section consists of six frequency - converter units, in each of which the output of a crystal-controlled oscillator is doubled and amplified preparatory to mixing with the keyed input from the drive unit in the balanced modulator stage. Sum and difference frequencies, now carrying the signal modulation, are passed to a preliminary linear amplifier, and then to the second transmitter section, comprising the main linear amplifier portion with low-power, penultimate and high-power sections. Negative feedback from the penultimate to the low-power amplifier gives a high degree of linearity for reduction of noise and unwanted phase modulation. These characteristics enable each transmitter to carry a number of channels simultaneously without mutual interference. Two grounded grid triodes are used in the final amplifier stage, eliminating the need for critical neutralising. The high-power valves are air-blast cooled, and the hot air can be recirculated to heat the buildings.

The transmitters feed into rhombic aerials, mounted in pairs one above the other on the same masts. Selection of any pre-set frequency in the transmitter automatically causes its output to be connected to the appropriate aerial. A frequency change by remote control takes less than a minute, or an average of twelve seconds if effected locally. For each change the mechanism drives until a balance is secured in a bridge network and is then arrested. Provision is also made by independent switching for using alternative aerial arrangements at the same frequency so that signals may be beamed by the most suitable path according to time of day and other conditions.

Power supplies are taken from the public mains at 11kV. Two English Electric 750kVA diesel-alternator sets with compressed air starting have been installed recently for standby supplies, and the power house is equipped also with a 12·5kVA set consisting of an Armstrong-Siddeley engine driving a Crompton Parkinson alternator with " Magnicon " exciter, which starts automatically in case of mains failure to maintain a supply for station lighting at 240V.

LITERATURE

Book Reviews

Progress in Non-Destructive Testing. Edited by E. G. STANFORD and J. H. FEARON. Heywood and Co., Ltd., Ingersoll House, 9, Kingsway, London, W.C.2. Price 60s.

PERIODIC progress reviews of various specialised fields of science and technology are now an established feature of the modern literature and are invaluable in providing a digest of the voluminous information in any one field and in leading the reader to marginal fields of potential interest. For these reasons this first volume of a proposed series of reviews of progress in non-destructive testing will be welcomed by many, but particularly by physicists concerned with research and development work in this field. The title of this book however may be misleading to engineers and technologists seeking practical guidance in the selection and application of new or modified non-destructive testing and quality control techniques. This the review does not set out to do, and while three and possibly a fourth of the eight articles contain material of direct technological significance, the contributions are mainly from physicists not directly involved in industrial non-destructive testing and deal primarily with fundamental physical aspects and physical significance of the various techniques. While the editors state their position clearly in the cover statement and in their foreword it is a pity they were not able to adopt a title which would indicate more clearly the nature of the contents of the book. Again the editors' wide interpretation of the term "non-destructive" will not be generally accepted and laboratory tests involving the preparation of a specimen test piece or coupon samples are no more non-destructive in the technological sense than tests of mechanical properties or chemical analysis, though it may well be that such physical tests, if they prove significant, could be developed for true non-destructive testing and quality control of production material.

The first article presents an excellent review of factors controlling the sensitivity and scope of various X-ray fluoroscopic techniques of flaw detection, when used under controlled laboratory conditions, and proceeds to compare these techniques with the present and potential performance of systems involving the use of electronic image intensifiers. On the basis of comparison adopted these newer techniques appear to present only a small gain in sensitivity, though they do enable greater thicknesses of material to be examined. However, the author does not emphasise sufficiently the considerable advantage that these techniques provide in industrial inspection where the conditions of operation may not compare with those in a research laboratory and where maximum sensitivity may not be the chief criterion.

The article on the stress wave propagation aspects of ultrasonic flaw detection presents a clear statement of the classical theory of the propagation of plane elastic waves and their reflection and refraction at boundaries. It is clearly not yet possible to present any other theoretical treatment and the author is thus able to give only a qualitative description of the behaviour of transient pulses of finite width. The most interesting part of this article covers the author's own experimental work on the pressure amplitude distribution in primary ultrasonic beams.

The third article, by an American author, deals with electromagnetic or eddy current testing and presents a very detailed discussion and analysis of such basic aspects as electromagnetic induction, skin effect, the physical parameters determining the impedance of test coils and of the problems of signal analysis. It has the unwarranted distinction of being by far the longest article in the book and could usefully have been reduced considerably. It deals with the theoretical aspects very thoroughly and presents clearly the theoretical variations of the X/R impedance plots with variations in material properties including permeability for ferromagnetic materials. The discussion of the practical applications in production is disappointing and one would like to see a more detailed description of practical techniques and more particularly of practical procedures for the application of a technique which is all too frequently suspect because of its misuse. It is disconcerting to find the author stating that in precipitation hardening alloys the resistivity decreases on ageing. This is certainly not true for the early stages of hardening of some of the aluminium alloys.

The assembled data in the article on neutron radiography are very useful, particularly the absorption data and data on non-reactor sources of neutrons. The latter data may encourage workers outside the atomic energy field to study these techniques and so establish their full potentialities, but it is clear from this article that the principal limitation lies in the lack of suitable sensitive recording media. It would have been useful if the author had given some indication of any significant radiation damage effects if these are relevant.

The article on the applications and interpretation of damping capacity measurements gives a brief survey of laboratory applications of these techniques to a very wide range of materials including metals and alloys, plastics, semi-conductors, ferro-magnetic and ferro-electric materials and ferrites. While these techniques in their present form cannot be regarded technologically as non-destructive testing methods they present such valuable approaches to the study of structural variations in materials that they may well lead to the development of tests suitable for application in production.

The article on thermal conductivity measurements describes a number of techniques which are essentially established laboratory methods, but also introduces a thermal comparator developed by the author which promises to be useful in a number of industrial applications. One application in particular which has hitherto caused some difficulty, namely, the depth of the hardened layer in case-hardened steels, may well be resolved by this method.

Two other articles, one on medical non-destructive testing and the other on nuclear magnetic resonance, while extremely interesting are somewhat out of context in a book of this title.

While one may criticise the inclusion of some of the articles and the omission of others, notably X-ray fluorescence analysis, this book is commended as providing a valuable and up-to-date source of information and references on the physical aspects of some techniques of current or potential importance in the assessment of materials.

Missile Engineering Handbook. By C. W. BESSERER. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 109s.

THIS is one volume of a series of nine under the general title of *Principles of Guided Missile Design*. The other eight are intended to cover various specialised aspects of the subject in a manner suitable for giving graduate level readers a comprehensive grounding in the techniques and practice involved. At the same time an effort has been made to link the different volumes through the "weapon system" concept and to some degree the present volume forms an important part of this link.

It is quite definitely a handbook for those who are already familiar with one or more divisions of missile design and in no way a text book which can be used to develop an *ab initio* understanding of the subject. It is packed full of data and facts which are relevant to missile design, performance and operation. These facts are recorded in ten chapters which, apart from those to be expected on aerodynamics, propulsion, materials, structures and electronics, also include properties of the atmosphere, environmental data, reliability, space flight data, and a glossary. All are treated in a complete and concise form and where tables or graphs are given, these are adequate to permit accurate figures to be read from them. It is probable that the specialist will not find much in the chapter dealing with his speciality which will be of great value to him, but it is almost certain that he will find much in the remainder of the book which can help to tie in both the features which are obviously associated and those which are less clearly so. There is, of course, a good deal of material which is purely of U.S.A. interest, such as the lists of specification numbers, military nomenclature systems, and manufacturing treatments. It is also important to bear in mind that Americans still use the Fahrenheit temperature and heat units, although practically all missile work here is based on Centigrade units.

A section of the book which will be found of great value to almost everybody is the glossary of 160 pages. It contains both simple and abstruse terms, abbreviations and colloquial expressions, all of which are explained in admirable fashion. Some of them are Americanised words, such as "unitization" and others are coined. A good deal of amusement can be obtained by merely comparing the literal meanings with the definitions given of such words as, for example, "backscratcher" and "tail grab."

All the data included are, of course, unclassified, but it is surprising what a vast amount is available in the open literature when it is collected and collated as here. It is certainly adequate for preparing preliminary design studies or assessing the importance of any selected parameters. Even average human dimensions are all given and the space limitations for installing crew are illustrated. Analysis methods are all tabulated and they are particularly useful in giving the non-specialist an appreciation of the various features and problems of a design.

Hydraulic Turbines, Their Design and Equipment. By PROFESSOR MIROSLAV NECHLEBA, Dr. Tech.M.E. Artia-Prague. Constable and Co., Ltd., 10–12, Orange Street, London, W.C.2. Price 45s.

PROFESSOR NECHLEBA of the Hydraulic Machinery Institute at the Slovak Technical University in Bratislava, is best known in Western Europe for his original high-head Kaplan designs, but this inexpensive treatise in English and references to others in the bibliography, reveal the scope of his work on hydraulic turbines. The last English text books on hydraulic turbines by Gelpke and Van Cleve (1911), and Daugherty (1920), together with classical French and German works such as Tenot (1935), Thomann (1935) and Camerer (1924) on turbines and Fabritz (1940) on governing are now out of date and a new one has long been needed. Elementary mathematical methods provide theoretical approaches to hydraulic questions and special attention is given to mechanical design and numerical examples which make the book of great value to designing engineers, draughtsmen and students. A brief review of the four parts into which the book is divided will show the nature of the problems which are dealt with.

Part I is devoted to fundamental hydraulic turbine theory and covers in 122 pages forces and moments in stationary-revolving ducts and output control illustrated by diagrams and drawings of Francis, Propeller, Kaplan and Pelton turbines. The sections concerned with hydraulic similarity, specific velocities and specific speed and their relation to efficiency variations in terms of turbine dimensions and head and subsequently to generalised topographical performance diagrams based on unit values will be welcomed by the non-specialist engineer. They embrace the theory of the Moody and Camerer step-up formulæ and mention Hutton's work on Kaplans. Friction, shock and discharge losses are introduced in the algebraic and geometrical analysis of runner inlet/outlet triangles and their application to Francis and Kaplan turbines.

In Part II of 300 pages Francis turbines set the basic pattern for consideration of the hydraulic and mechanical design of elements, such as spiral casing, guide apparatus and draught tube, which are common to all reaction turbines. The one- or two-dimensional theory as well as meridional flow fields, velocity triangles, constant circulation and conformal representation are used for low and high specific speed Francis runner design to determine inlet/outlet diameters and edge position, blade and passage shape and dimensions, and the influence of the draught tube and oblique guide vane discharge, all of which are correlated into a blade layout procedure illustrated by numerical examples.

An original analysis of blade strength based on applied forces and stresses, replaces the empirical Camerer and Thomann formulæ. Other essentially hydraulic/mechanical problems such as labyrinth leakage losses, shaft loads and critical speeds are analysed mathematically and coupled with empirical formulæ where applicable. The shape and number of guide vanes and their resultant open and closed position moments are calculated in terms of their minimum loss and constant contraction profile characteristics. The controlling mechanism is elegantly analysed mathematically to ascertain the guide vane and regulating ring mechanical design loads. Finally the spiral casing shape in association with the stayvanes and guide vanes are examined from the standpoint of hydraulic theory and the treatment extended to the loading, stressing and dimensioning of these components, together with the inner and outer covers. It would seem from the cavitation theory outlined that research is being concentrated on mechanical fatigue, intercrystalline corrosion and similitude of model and prototype cavitation.

The theoretical design of propeller and Kaplan turbine runners utilising the properties of NACA Report 460 Aerofoils extended to lattice system conditions is a notable addition. The turbine space shape, embracing the runner hub, chamber, cover and guide vanes are studied in relation to meridional flow fields and surface velocity diagrams to ascertain the number of blades and hub ratio in terms of head and specific speed. Blade and shaft stresses, hydraulic thrust, hub, bearing, shaft and inner cover design, are skilfully and concisely analysed. Shalnev's work is used to explain blade flow stability and blade gap cavitation.

Ing. M. Druckmuller gives a competent treatment of Pelton turbines in some sixty pages covering specific speed, jet and wheel diameter and bucket design with an analysis of jet and centrifugal forces in relation to lug and bolt dimensions. The active forces concerned with the hydraulic and/or spring-loaded operating mechanism design for the needle, nozzle and deflector dimensions are also calculated.

Part III on turbine equipment includes a valuable section on governors and their auxiliaries and the principles of servomotors, differential control valves, restoring mechanisms, speed sensitive devices and electrical drives. A further section based on Nechleba's *Theory of Indirect Speed Control* (1952), briefly introduces the problems of speed and pressure regulation, stability and matching of machine and governor characteristics to network requirements. A chapter by Ing. J. Urban on thrust and guide bearings outlines hydro-dynamic lubrication theory with illustrations of actual designs and references to segment and collar materials, oil characteristics, generator brackets and oil/water cooling arrangements. The section on pipeline and surge chamber questions and the fundamental approach to waterhammer theory using the Schnyder Bergeron diagrams and Schoklitsch's graphical method will attract the attention of turbine and governor designers since it should make immediate reference to advanced texts unnecessary for preliminary work.

Part IV deals, in five pages, with the principal aspects of commissioning a unit for the first time and methods of flow measurement.

The book makes many references to Russian and Czechoslovak publications and gives an interesting glimpse of Eastern European designs and the extent to which western techniques are being applied. It is printed in Czechoslovakia in clear type with admirable diagrams and drawings and is adequately indexed. The excellent translation is marred only by a few minor but distracting errors, correction of which would give easier understanding of an otherwise outstanding and welcome contribution to the long neglected field of hydraulic turbine literature.

Examples of Student and Graduate Apprenticeship Schemes in Mechanical Engineering. THE INSTITUTION OF MECHANICAL ENGINEERS, 1, Birdcage Walk, Westminster, London, S.W.1.

THIS is a brochure prepared by the Institution of Mechanical Engineers primarily to provide information for headmasters of schools, youth employment officers and parents about engineering apprenticeship schemes in mechanical engineering. Definitions are given of what is meant by student apprentices and graduate apprentices and the kinds of "sandwich" schemes are described. For the rest the publication consists of tabular matter listing the firms offering apprenticeships, the firms' products and the age limits and entrance standards for the two kinds of apprenticeship, duration of the apprenticeship and in the case of student apprenticeships details of day release, &c., whether the course is of the sandwich variety and what qualification it leads to.

Hochwertiges Gusseisen (Grauguss). By EUGEN PIWOWARSKY. Second edition. Springer - Verlag, Berlin - Wilmersdorf, Heidelberger Platz, 3. Price DM.135.

THIS important standard work on cast iron made its first appearance in its second, completely revised edition, in 1951, and after having been out of print for several years has now been reprinted. The 1100-page work, condensed from a manuscript of originally 1400 pages in order to keep the price within acceptable limits, deals comprehensively with the physical and chemical technological properties of cast iron, its structure, the effects of heat-treatment and corrosion, and protection against the latter, hot and cold plastic working, welding, production of cast iron in the cupola and other furnaces, and casting. Extensive chapters are devoted to alloy irons and cast irons with spheroidal graphite. The fact that this book is again available will be welcomed by many.

Books Received

Crushing and Grinding. Compiled by W. H. Bickle. H. M. Stationery Office. Price 35s.

Accelerators of Ions and Electrons. By C. Simane. Constable and Co., Ltd., 10, Orange Street, London, W.C.2. Price 16s.

Radiations and Matter. By André Berthelot. Leonard Hill (Books), Ltd., Eden Street, London, N.W.1. Price 25s.

Cast Tools. By Z. Eminger and V. Koselev. Constable and Co., Ltd., 10, Orange Street London, W.C.2. Price 20s.

Year Book of the Heating and Ventilating Industry. Technitrade Journals, Ltd., 8, Southampton Row, London, W.C.1. Price 10s. 6d.

The Directory of Opportunities for Qualified Men, 1959. Cornmarket Press, Ltd., 1, Lower James Street, London, W.1. Price 8s. 6d.

Cores and Coremaking. By F. D. Roper. George Allen and Unwin, Ltd., Ruskin House, Museum Street, London, W.C.1. Price 21s.

Bergbaumechanik. 5th Edition. By W. Ostermann. Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf, Germany. Price DM.36.

Introduction to Dock and Harbour Engineering. By Rolt Hammond. Thomas Nelson and Sons, Ltd., Parkside Works, Edinburgh, 9. Price 25s.

Diesel Plant Operators Handbook. By A. K. L. McCrone. Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price 20s.

Kinematisch-Getriebeanalytisches Praktikum. By Rudolf Beyer. Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf, Germany. Price DM.28.50.

A First Year Engineering Drawing. Sixth edition. By A. C. Parkinson. Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price 9s.

Grenzschichtforschung. Iutam Symposium Freiburg/Br. 1957. Edited by H. Gortler. Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf, Germany. Price DM.67.50.

Progress in Nuclear Energy, Series 1, Vol. 2, Physics and Mathematics. Edited by D. J. Hughes, J. E. Sanders and J. Horowitz. Pergamon Press, Ltd., 4 and 5, Fitzroy Square, London, W.1. Price 90s.

Radiation Biology and Medicine: Selected Reviews in the Life Sciences. Edited by W. D. Claus. Addison-Wesley Publishing Company, Reading, Massachusetts, U.S.A., and Academic Books, Ltd., 129, Queensway, London, W.2. Price 11.50 dollars.

OBITUARY

PROFESSOR A. H. GIBSON

DR. ARNOLD HARTLEY GIBSON, whose death, we regret to record, occurred on February 17 at Alderley Edge, Cheshire, spent by far the greater part of his professional career as a teacher of engineering. At the time of his death he was Emeritus Professor of Engineering in the University of Manchester, where he had graduated in 1903. Professor Gibson, who was in his eighty-first year, received his general education at Rishworth Grammar School, and then served an apprenticeship in mechanical engineering. After gaining his B.Sc. degree at Manchester, he was for a time head of the mathematics department at Salford Technical College, becoming subsequently an assistant lecturer in engineering and hydraulics at Manchester University. Gibson was awarded his doctorate in 1909, in which year he was appointed professor of engineering in the university of St. Andrews. He continued in that position until 1920, though he was away from St. Andrews during the first world war, serving with the Royal Field Artillery as a captain, and from 1916 to 1919 being officer-in-charge of aero-engine research at the Royal Aircraft Establishment. In 1920 he returned to Manchester University as Beyer Professor of Engineering, a post which he held until his retirement in 1949.

Professor Gibson's career will be primarily remembered for his contribution to the science of hydraulics. In fact, he studied under Osborne Reynolds at Manchester, and later on, as a professor, he was able to carry on the academic tradition of Reynolds' researches at that university. Gibson's researches in hydraulics were prolific, covering many aspects of that subject, and his writings are correspondingly varied and abundant. He will probably be most widely known for his textbook *Hydraulics and Its Applications*, which was first published in 1908, and which, after undergoing many revisions and new editions, is still in demand to-day. Forty years is a considerable life for a textbook, and is, indeed, remarkable when it covers a subject in which rapid advance is being made. Until quite recent years, the book was the only comprehensive text of its kind, and it is unusual for the quantity of original research incorporated in its chapters. One of the principal fields of application of hydraulics, that of hydro-electric engineering, was also a speciality of the professor's, and he edited a textbook on this subject which was a standard work for many years. He served on a Board of Trade committee which reported on the water power resources of the British Isles in 1921.

Apart from a comprehensive contribution to the science of hydraulics generally, and one which undoubtedly raised the status of British study in that field, Professor Gibson was chiefly associated with hydraulic model research, particularly with tidal models. His best-known investigation was that of the Severn estuary, and of the effects of the proposed Severn barrage. His report on this work was published in 1933 after more than five years' work; we commented at the time that the report "formed a record of experiments with estuary models hitherto unparalleled, certainly in this country, and not, we believe, equalled in wealth of detail by any records published in other countries." The principal model had a horizontal scale of 1 in 8500 and a vertical scale of 1 in 100; two problems especially discussed were the supply of silt and the effect of salinity. Professor Gibson was concerned with the Severn model investigations and similar ones arising from them involving models of the Dee, Mersey, Humber and Parrett estuaries, for the rest of his professional life. The success which he had with the investigations has since proved significant in influencing future trends in hydraulic engineering and in research with tidal models.

Professor Gibson was a member of both the Institutions of Civil and Mechanical Engineers, and an LL.D. of St. Andrews and of Manchester Universities. His published works include a number of papers before the learned societies, principally the Institution of Civil Engineers, and he was awarded the Ewing medal, a Telford premium, and a Crampton prize by that Institution.

A. G. M. MICHELL

WE have learned with regret of the death of Mr. Anthony George Maldon Michell, which occurred at his home in Melbourne, Australia, on Tuesday, February 17. Mr. Michell, who was eighty-eight, is particularly well remembered for the outstanding contributions which he made during his long career as an engineer to the theory and practice of lubrication.

Mr. Michell's education began in the State School, South Yarra, Victoria. At the age of fourteen he came to this country to attend the Perse School at Cambridge, following which he spent a year as a non-collegiate student of the University. During that year he attended lectures by J. J. Thomson and subsequently returned to Australia to study at the Melbourne University Engineering School. He started to practise as a consulting engineer in Melbourne in 1903, gaining experience in various aspects of hydraulic engineering. In the succeeding years, Mr. Michell was responsible for a number of inventions, including a water turbine, a viscometer and the thrust bearing with which his name has become prominently associated over the years. Another of his inventions was a crankless engine.

Mr. Michell was the author of many technical papers and books, the most recent of them being *Lubrication, its Principles and Practice*, which he completed in 1951. He was elected a Fellow of the Royal Society in 1934 and in 1938 he received the Kermut Medal of the University of Melbourne. Four years later, on the unanimous recommendation of the council of the Institution of Mechanical Engineers, Mr. Michell was awarded the James Watt International Medal for "his outstanding achievements as a scientist, a mathematician of international fame, an inventor and a producer."

SIR GEORGE BEHARRELL

SIR GEORGE BEHARRELL, who died at Harpenden, Hertfordshire, last Friday, February 20, was one of this country's prominent industrialists. He was an authority on transport matters, spent many years in the rubber industry and, during both world wars, occupied important posts in Government service. Sir George was eighty-five.

John George Beharrell was born at Almondbury, near Huddersfield, and began his education at King James's School, Almondbury. He left there at the age of fifteen to join the clerical department of the North Eastern Railway at York, a post which he later relinquished in order to study at Leeds University. He subsequently returned to the North Eastern Railway Company and, by 1914, was assistant goods manager and commercial agent at York. In the following year, Sir George was appointed to the Ministry of Munitions as director of statistics and requirements and shortly afterwards went to France as assistant director-general of transportation. In the later stages of the first world war, Sir George was transferred to the Admiralty as director of statistics, his work being primarily concerned with the U-boat menace to British shipping. After the war, Sir George (who was created a knight in 1919) joined the newly-formed Ministry of Transport as director-general of finance and statistics and in 1921 served as financial adviser to the Geddes committee on national expenditure.

Sir George left the Civil Service in 1922 to join the Dunlop Rubber Company. He became managing director of the company in 1923, chairman in 1937, and from 1949 until 1957 was the company's president. During his thirty-five years of service with Dunlop, Sir George filled many public offices, including president of the India Rubber Manufacturers Association, president of the Society of Motor Manufacturers and Traders, and president of the Federation of British Industries. In 1935, he served as chairman of the Sixth International Congress for Scientific Management and, in 1938, he was appointed to the Prime Minister's Panel of Industrialists. During the second world war, Sir George was director-general of raw material controls at the Ministry of Supply.

LUIGI EMANUELI

SIGNOR LUIGI EMANUELI, a vice-president of the Pirelli Rubber Company, who pioneered the oil-filled high-voltage cable, died at his birthplace, Milan, on February 17, at the age of seventy-six.

After graduating in electrical engineering at Milan Polytechnic, when he was twenty-three, Emanueli started work with the Pirelli Company. Two years later he presented a paper at the Associazione Elettrotechnica Italiana summarising his work on losses in dielectrics subjected to alternating potentials. He applied the results of these studies to power cables and the measurements he made led him to discover the phenomenon of ionisation. In his work on insulating materials and, in particular, paper, he established the relationship between its porosity and its dielectric strength. He showed that this porosity could be turned to good account by impregnating paper insulation with certain compounds, thus reducing ionisation and increasing the dielectric strength, so that cables could be made to operate at much higher voltages than formerly. Oil-impregnated paper proved to be a particularly effective insulant and the first oil-filled cable was put into commission shortly after his appointment as chief engineer of the Pirelli Company in Milan in 1917 at

the age of thirty-four. Two years later he also became chief engineer of the associate Pirelli Company in Great Britain.

Although most of Emanueli's discoveries were of special application to power cables, he also did much pioneer work on telephone and telegraph cables. For instance, in 1910 he was responsible for the design and installation of a twin conductor continuously-loaded telephone cable linking Milan with a hydro-electric station 150 miles distant.

Emanueli was president of the Associazione Elettrotechnica Italiana from 1933 to 1935. In November last he became an honorary member of the American Institute of Electrical Engineers. Less than a month ago the council of the Institution of Electrical Engineers, London, announced that the thirty-seventh award of the Faraday Medal would be made to Emanueli for his outstanding contribution of inventions and new applications in electrical cables and particularly for his invention of the oil-filled cable.

E. F. G. COX

MR. ERNEST FRANK GUELPH COX, who died at Torquay on February 17, aged seventy-five, was an acknowledged expert in the salvaging of sunken ships. He was the founder of Cox and Danks, Ltd. (now part of the Metal Industries group), a firm which was started in the 1920s when Mr. Cox was engaged in raising the scuttled German battle fleet in Scapa Flow. Mr. Cox was born at Wolverhampton and was trained as an electrical engineer. During the first world war he was engaged in munitions production, and in 1919 he entered the scrap metal trade. In 1922, Mr. Cox set up a shipbreaking yard at Queenborough, Kent, and subsequently purchased from the Government a 40,000-ton floating dock which had been handed over by Germany as reparations.

It is said that while this dock was being dismantled at Queenborough, Mr. Cox decided it would be ideal equipment for raising the scuttled German warships from Scapa Flow. The floating dock was thereupon towed the 700 miles to Scapa and redesigned and converted to a floating workshop. By this time, Mr. Cox had negotiated with the Admiralty for the purchase of the German ships. The first lot to be acquired consisted of twenty-six destroyers and two battleships, and the first vessel which Mr. Cox raised from Scapa was a destroyer of about 800 tons, a task which took ten days. After dealing successfully with a number of the smaller craft, Mr. Cox turned his attention to the bigger ships ; one of his notable successes during that phase of the operation was the raising of the battle cruiser " Moltke " which was upside down on the bottom. It was decided to attempt to raise her by using compressed air. It was discovered, however, after the first attempt had failed, that it was necessary to distribute the air on the port and starboard side, as required, for the ship to be raised successfully. For this purpose, lofty airlocks were erected on the ship's bottom to give access to the interior so that the longitudinal bulkheads could be made watertight.

Several accounts of these salvage operations were printed in our columns at the time they were carried out, between 1924 and 1929. A detailed description of the difficulties and ingenuity of the enterprise was given by Mr. Cox himself in December, 1932, when he delivered to the Institution of Mechanical Engineers the Thomas Lowe Gray Lecture entitled " Eight Years' Salvage Work at Scapa Flow."

An Engineering Application of Reinforced Resin

By J. C. NEWSON*

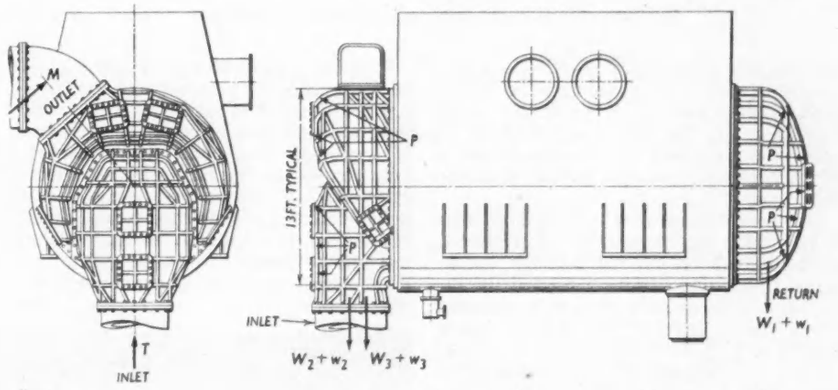
The author considers that the application of reinforced resin in heavy engineering should depend on practical tests to assess its suitability. Unsuitable applications, often involving arduous conditions, have resulted in a prejudice against the material. In this article, he explains his firm's development programme for one application, namely, the construction of water boxes for power station condensers. The use of reinforced resins in this application gives appreciable weight reduction and improved hydraulic characteristics, but these advantages are incidental to the main purpose behind the use of the new material, which is the elimination of graphitic corrosion. The programme extends to water boxes for the condenser of a 120MW turbo-alternator set.

THE entry of reinforced resins into industry in this country can be truly said to have taken place in about 1947. For some four or five years applications were restricted to the aircraft and electronics industries, with some divergence into the realms of consumer products. Since these materials had their roots in the plastics industry, being non-metallic, their emergence has been through the channels of that industry and through approaches originally developed by plastics moulders and fabricators. The low physical strength, particularly at elevated temperatures, of plastics materials has generally precluded their use in heavy engineering. For this reason there appeared a gulf between the promoters of reinforced resin and potential users in the engineering industry. This obstacle can be overcome by assessing the physical characteristics of reinforced resins by practical tests which reproduce conditions normally encountered in service—for example, where large and continuous loads exist or components are subjected to immersion for very long periods in reactive liquids. This article describes such an approach and how, over the course of some three years, reinforced resins were considered, tested and ultimately introduced to deal with a major problem in electricity generating installations.

In 1955, a survey was commenced by the C.E.A. (now C.E.G.B.) to assess the effect of corrosion in the cooling water systems of turbo-alternator sets, particularly at coastal generating stations. The most serious aspect of this corrosion, known as graphitic corrosion, takes place in the cast iron surfaces of the main condenser and auxiliary condenser water boxes, and is particularly severe where water is used which has a high oxygen content. The problem is normally alleviated by the use of sacrificial electrodes or conventional protective coatings, but evidence exists which shows that if the latter, for any reason, break down, then attack is concentrated at the point of failure.

There are in the C.E.G.B. few known cases of water boxes or piping in cooling water systems failing due to weakening by corrosion. This is as a result of careful maintenance which ensures that components are replaced before failure actually occurs. Main condenser water boxes are, however, an essential part of the system, and therefore involve a shut-down during replacement. The ideal solution appeared to be to find a material which was non-metallic and non-conductive and, therefore, not subject to electro-chemical corrosion in any form. The choice was very limited. Few such materials have sufficient inherent physical strength to contend with the very considerable loads which main condenser water boxes have to withstand.

Reinforced resins were a possibility and so approaches were made to the members of the industry with an engineering background who had gained some experience in the new materials. It was at this stage that the South Western Division of the C.E.A. decided to have made a number of boxes for auxiliary condensers. It was at the time obvious that conditions involved in such a box bore no relation to those which existed in a main condenser water box, but it was

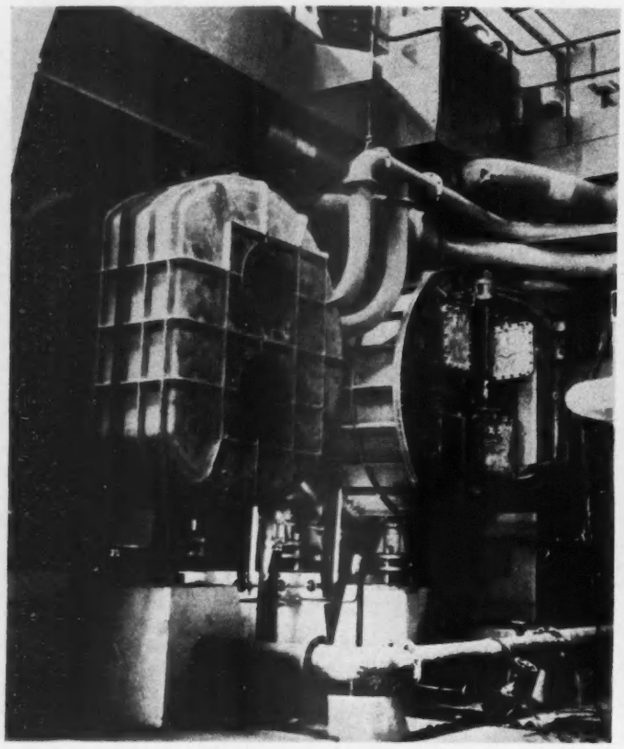


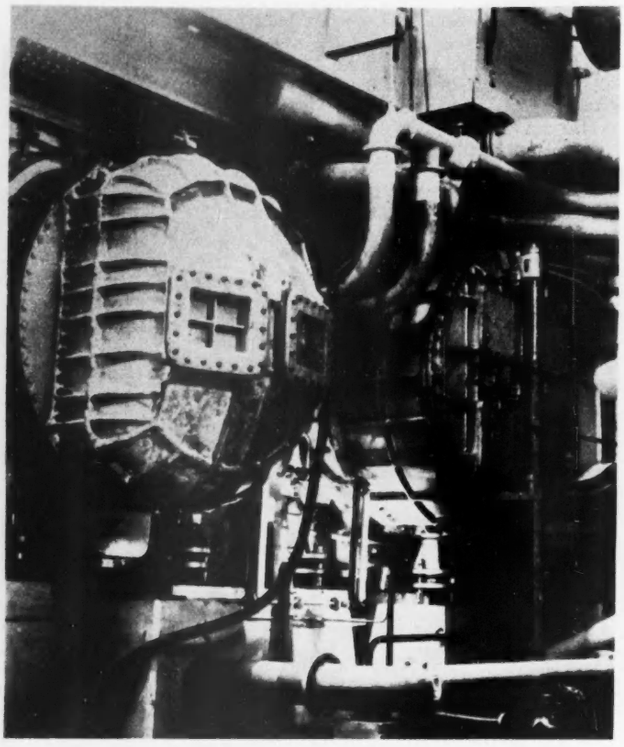
W = Weight of water.
w = Weight of reinforced resin box.
P = Test pressure.
M = Moments resulting from weight of cooling water, pipes and thrust due to thermal expansion.
T = Thrust resulting from thermal expansion.

Return			Inlet/outlet						
W_1, tons	w_1, tons	P_1, p.s.i.	W_2, tons	W_3, tons	w_2, tons	w_3, tons	P_2, p.s.i.	T, tons	M ft/tons
11½	3	40	6	6	1½	2¼	40	24	168

Loading diagram of typical main condenser water boxes

* Director, Mendip (Chemical Engineering), Ltd.





The first (left) and second (right) prototype reinforced-resin main condenser return end water boxes fitted to a 30MW set

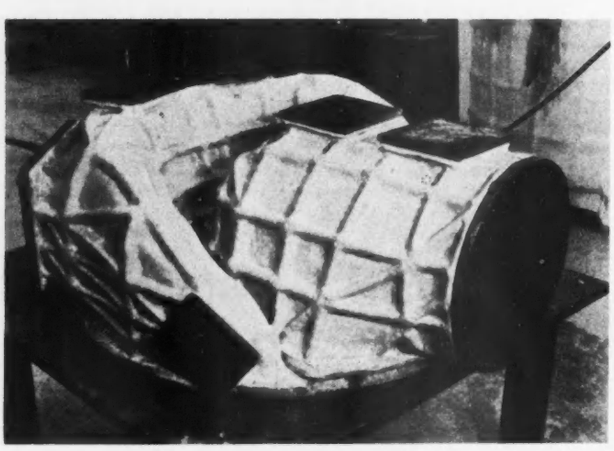
felt that this experimental installation would give generating station engineers the feel of the material and would contribute some knowledge on the abrasion resistance of reinforced resins, and on any selective attack which might take place on the tube plates or tube ends.

It is a very common mistake and one that has retarded the introduction of reinforced resins into the engineering industry that an initial application has been selected for the new materials which is extremely arduous, often where conventional materials have proved completely unsuitable. In consequence, the first attempt has failed, and a strong prejudice been created. In the case of the project under consideration, however, the small cooler boxes were installed in June, 1957, and sufficient time has now elapsed to establish that at least the effect on the tube and tube plates has not been more severe than when cast iron boxes were employed. These boxes are still in operation at Plymouth "B" generating station and continue to give results which will, in the course of time, provide most valuable information.

Main Condenser Water Boxes

To extend this work to main condenser boxes became logically the next problem. It was felt that the question of the material's compatability with cooling water had been established and a station with formidable difficulties from graphitic corrosion was selected for the next stage of the experiment, viz., the East Yelland station, which has six 30MW sets, and is cooled with estuarine water. The condensers are two-pass, and are fitted therefore at one end with an inlet/outlet box and at the other with a return end box. The design problems associated with the inlet/outlet box are much greater than those involved in the return end unit. As illustrated, at the inlet/outlet end, loads are sustained from five factors, while at the return end these are reduced to three, and the complication of a division does not exist.

Progress, it was once again decided, should be as prudent as possible, and the return end box was chosen for replacement. Since there is doubt about the creep characteristics of reinforced resin under heavy loads for long periods, on the basis of contemporary knowledge, a design was chosen which reduced risks in this direction to a minimum. It must be realised that to produce a casting in reinforced resins of this size and to these requirements was at the time unprecedented.



Scale model of inlet/outlet box

The familiar production of boat hulls of larger dimensions had little relationship, the working loads involved being entirely different. The three important questions were—could a casting of this size be produced at a price which would make the project economically feasible; could the site manipulation required be carried out; and would the installed unit work? The first prototype, intended to provide an answer to these questions, was put into service on September 27, 1957. In fact, this prototype box was satisfactory for all normal economic and operating requirements, but it failed under shock load on October 6, 1957.

On analysis, it was recognised that although the damaged box could have been repaired, the lessons which had been learned were of such value that there was a considerable advantage to be gained in making a redesigned box. A second prototype was installed on August 26, 1958. Both of these installations are illustrated herewith.

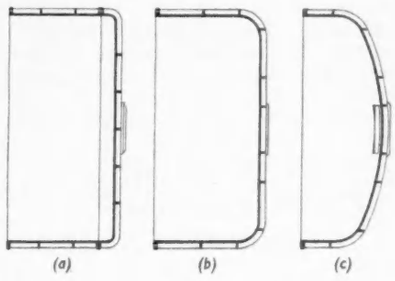
After a hydraulic test at 40 lb per square inch had been applied and held on the second prototype, it was established that the maximum point deflection was 0·116in. This was considered very satisfactory and the condenser has subsequently operated continuously under load. Before production of the second prototype was commenced a considerable development programme was instituted by the manufacturers. The initial results from this, together with the background knowledge which had become available, resulted in a decision by the Northern Project Group, C.E.G.B., to pursue this development and install both inlet/outlet and return end boxes on the 120MW sets under construction for Blythe "A" station. The manufacturers of the boxes undertook to construct a quarter-scale model of the inlet/outlet box for testing, even to destruction, if necessary. The model is illustrated.

This work was initiated in 1958, but it was

decided by July, 1958, that insufficient work could be done in the time, limited as it was by the commissioning date, to put the inlet/outlet boxes in the classification of being a calculated risk. The return end boxes which had a diameter across the main flange of 13ft were completed to schedule on August 31, 1958.

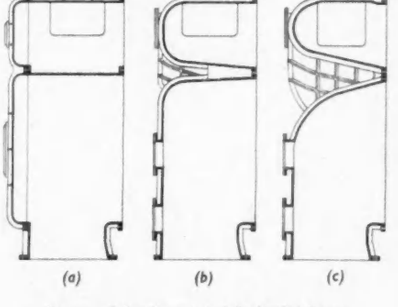
Development of Design

The development of design permitted by the use of reinforced resin in the case of water boxes has been very rapid. In the case of the return end this occupied three phases, as illustrated. The conventional design (*a*)



Stages of development, return end water boxes

produced normally in cast iron had two bolt circles, one for mounting on to the tube plate, and one to permit removal of the cover. With increasing size the cover became so heavy that it was necessary to fit a hinge gear so that tube maintenance was not dependent on the station service crane being available. The first amended design (*b*) in reinforced resin eliminated the cover, as it was found that at the design weight a small auxiliary manual lifting gear could meet all requirements. It is, with this design, preferable that the main flange fixing is on to studs so that removal of the box does not interfere with the joint between the tube plate and the shell. If shouldered studs are used the main flange of the box can be machined to accept the enlarged diameter. The final design of return end box (*c*) gives a unit one-sixth of the weight of cast iron which permits



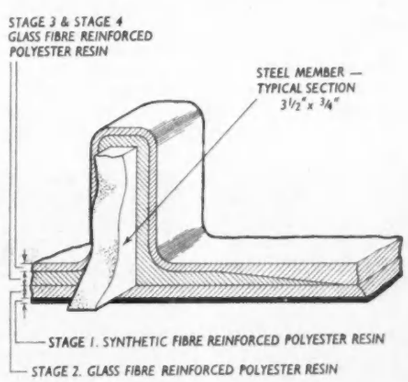
Stages of development, inlet/outlet boxes

streamline flow and direct access to the tube ends, in addition to eliminating completely the possibility of graphitic corrosion. This method employs half the number of nuts and bolts otherwise required and only one main joint.

The return end boxes gave considerably more scope for re-design, particularly when the shape of the boxes could be considered concurrently with the other controlling factors, the tube plate and feed water pipes.

The cast iron inlet/outlet box (*a*) in the illustration on this page is identical in shape to the return end box but with the addition of the ports and a division plate. To adapt reinforced resin to conventional tube plate design, the cleft design (*b*) was evolved. When provision was made for two lines of bolts across the tube plate the final stage could be reached (*c*). The advantages thus gained are that the box is in two units, each of which can be removed separately for tube servicing. Minimum turbulence is obtained and the weight reduced to one-seventh. There is a considerable manufacturing cost reduction in the final stage, as relatively small, easily accessible castings are involved.

The difficulty in making stress calculations on these complex shapes is apparent. This was increased by the heterogeneous nature of reinforced resin, which can give rise to considerable variation in strength. It was decided to eliminate this variable by carrying the principal loads through to a steel cage. This cage is fabricated of rectangular section members with the major axis normal to the surface of the finished shape, and it eliminated stresses, other than those caused by diaphragm loads, on the panels. In calculating the section thickness of these panels it was decided to allow a working stress of 2000 lb per square inch in the grade of material used. The ultimate tensile strength of samples made in the laboratory was consistently above 12,000 lb per square inch but this was reduced by a factor of 6 to allow for operation under wet conditions with a possibility of high temperatures, variable quality


STAGE 3 & STAGE 4
GLASS FIBRE REINFORCED
POLYESTER RESIN
STEEL MEMBER —
TYPICAL SECTION
3½" x ¾"
STAGE 1. SYNTHETIC FIBRE REINFORCED POLYESTER RESIN
STAGE 2. GLASS FIBRE REINFORCED POLYESTER RESIN

Section showing construction for inlet/outlet box

and complex stresses resulting from bending loads. The steel used has an ultimate tensile strength of 26 tons per square inch. The acceptance test is 20 tons per square inch and the welding technique gave consistent results of 20 tons per square inch. Reducing these figures by a safety factor of 4 gave a working stress of 5 tons per square inch. The composite construction is shown diagrammatically above.

Loads are transferred from the edge-on steel members to the steel reinforcing ring in the main flange by gusset plates. Manufacture is preceded by the production of scale models so that the shape can be developed and agreed. A mould or former is then made conforming to the inside shape of the box. Should one or two boxes only of the same shape be required, the mould would be of plaster. If larger numbers are required, the mould would itself be produced in reinforced resin. After the surface of the former has been treated to avoid adhesion with the casting, the initial layers of synthetic reinforcing and polyester resin are applied to a thickness of 0·1in, in the case of the box shown in the illustration. This is followed by glass fibre and polyester resin to a thickness of 0·4in. The quantity of accelerator and catalyst added to the resin is adjusted to give a slow rate of cure at room temperature.

When this stage has been completed and the casting semi-cured, the steel is fitted. As far as is possible the steel is prefabricated, but where this is not practicable, members are welded in position. During welding a thin metal plate is used between the steel frame and the casting to dissipate heat and avoid local burning. Gaps which exist between the steel and the first part of the casting are filled with a heavily loaded resin which also serves to provide a fillet at the point of contact. Glass fibre and resin is then applied locally over the steelwork and the general thickness is increased to a theoretical 0·9in. After partial curing the casting is removed from the mould. The release agent is removed from the surface of the main flange and the box lowered on to a wet resin and glass mixture prepared on a 15ft square ground steel slab. This produces a flat surface, requiring no further machining. The completed box is then cured with hot air. It is at present customary for the drilling required to be carried out by the condenser manufacturers as this must be related to the drilling of the tube plate.

Kent Refinery.—A thermal reformer designed by the Kellogg International Corporation, London, has recently been placed on stream at the Kent refinery of the British Petroleum Company, Ltd. The thermal reformer, of 12,000 barrels per day capacity, is designed for single-pass thermal reforming of light or heavy naphtha fractions from Middle East crudes to produce a debutanised reformate of maximum research octane rating. Effluent from the reforming furnaces, of which there are two to ensure continuous operation, is separated in the main tower into heavy bottoms liquid and an overhead vapour product. The former is stripped of its lighter components to produce fuel oil, while the latter is clay treated to remove undesirable polymers and passed on for final fractionation in an after-fractionator, a debutaniser and a depropaniser.

Development Projects in Australia.—The Australian Department of National Development has published a booklet (copies of which are available at Australia House, Strand, London, W.C.2) entitled *Major Development Projects in Australia*. It gives details of major projects under construction in Australia at the end of last June, and also lists those new projects completed since 1956 when the previous edition of the booklet was published. Brief notes are given on the nature of each work, its purpose, the progress reached, the addresses of the responsible authorities, and, wherever possible, the estimated costs. A map shows the disposition of all works. Although only the most important works are included in the survey, the total number now described is 257. They are summarised under the headings of water conservation and supply and irrigation; electricity generation; gas; railways; bridges; ports; airports; and land settlement. Most of the works are being carried out by State government departments and "instrumentalities." However, some gas and land settlement undertakings are being carried out by private enterprise. Cost estimates—not related to the annual expenditure—are available for 149 of the 179 works. It is estimated that these 149 works will cost £760 million to complete. The Snowy Mountains hydro-electric scheme, with an estimated cost of £400 million, is not included in this total. Types of undertakings of which the estimated cost is available and which are detailed in the publication include the following: Water conservation supply and irrigation, £215½ million; electric generation, £415 million; railways, £63,000,000; ports, £47,500,000; bridges, £12,500,000; airports, £3,000,000; gas production, £3,000,000. The cost of major works in Australia which have been completed in the two years since the last edition of the publication is estimated at £235 million. Amongst the works in progress at publication of the booklet were: Warragamba Dam to augment Sydney's water supply, £25,000,000; Mareeba-Dimbula irrigation scheme, North Queensland, £20,000,000; Lake Macquarie power stations near Newcastle, N.S.W., £60,000,000 (minimum cost); Hazelwood power station in Victoria, £100 million; Melbourne-Wodonga rail standardisation, £10,000,000; first stage development of all-weather port at Port Kembla, N.S.W., £5,000,000; a similar project at Portland, Victoria, 5,000,000.

High-Voltage Laboratory for Power Cables

A high-voltage laboratory has been set up to form an integral part of the new power cable works which is nearing completion by British Insulated Callender's Cables, Ltd., at Erith, Kent. All the development and proving tests required by the power cable division will be concentrated at Erith in the new laboratory. The test equipment includes a 3·2MV impulse generator, a smaller impulse generator and an 800kV power-frequency test set consisting of two 400kV transformers with controlled series resonance. Present and future requirements for tests on power cables operating at 400kV and above are well within the capacity of the laboratory.

WITH the setting up of the power cables division of B.I.C.C. in 1955, it was decided to reorganise the cable-making activities of the company and concentrate the manufacture of power cables at Erith, Kent. Subsequently a development programme involving the rebuilding of the power cable works at Erith was put in hand, and is now well advanced. An important part of this development is the new high-voltage laboratory which is described and illustrated here and is now in operation.

As an integral part of the new cable works, this laboratory is equipped for development tests and proving tests on power cables up to 400kV. The new laboratory, with its improved facilities, has more than enough capacity to handle all the power cable testing work formerly done at the two B.I.C.C. laboratories at Prescot and Wood Lane. The Prescot laboratory has been closed and the high-voltage test equipment at Wood Lane (which has hitherto been much used by the company's power cable division) will now be available exclusively for other research work, particularly on materials.

The major items of new plant in the laboratory are a 3·2MV impulse generator and an 800kV a.c. testing set ; the space required for these items and, in particular, clearances to walls and roof, was one of the major factors in determining the size of the building. Items of subsidiary equipment include two 200kV transformer test sets and a 640kV impulse generator. Soon this generator will be extended to 1280kV and a 76kV three-phase a.c. test set will be installed.

The Laboratory Building

The building is 200ft long and 108ft wide and rises to a height of 58ft to the apex and 37ft to the eaves. To arrange this structure and its heavy equipment on a marshy Thames-side site posed problems which were solved by using a system of reinforced concrete piles (sunk to depths of 26ft in some instances) over the whole area occupied by the laboratory.

Portal frame construction was used for the main hall of the laboratory which has an unobstructed floor area (22,000 square feet) which is thought to be as large as that of any high-voltage laboratory in the world. There are no cranes in the building because the provision of interlocks and observation of high-voltage clearances would seriously restrict their operation. All lifting is done from a standardised form of frame scaffolding and lifting beam arrangement which can be rapidly erected to any required height. An example of frame scaffolding can be seen in Fig. 1. The roof frame carries a number of support points for suspending high-voltage busbars.

Reinforced concrete, clad in double-skin asbestos with surrounding dado walls of brick, forms the main frame of the building. An infill of fibre-glass mat 2in thick is used to maintain the necessary level of thermal insulation for the building, which is heated by five heat exchangers drawing in fresh filtered air from outside and maintaining a slight pressure inside to reduce the ingress of dust.

For the flooring use was made of structural concrete overlaid with a 4in-thick metal aggregate surface finish to provide the necessary hard-wearing qualities and dust-free conditions essential in a laboratory of this kind. It will carry a point load of 6 tons anywhere over the surface of the laboratory, and certain sections are strengthened to carry the added load of the test equipment. An area at one end of the building is arranged to carry a mobile load of 60 tons spread over four points. For convenience, the reinforcing steel over the whole floor is electrically welded together to provide a ground plane which is used as an electrical measurement

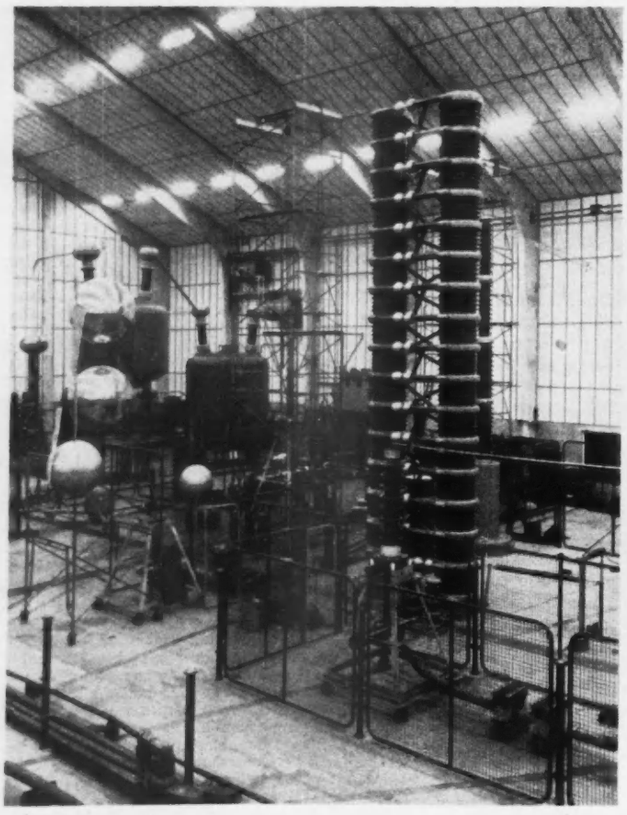


Fig. 1—High-voltage laboratory as seen from control room, showing 800kV, 2MVA, 50 c/s testing set (background, left), and 3,200,000V impulse generator (right)

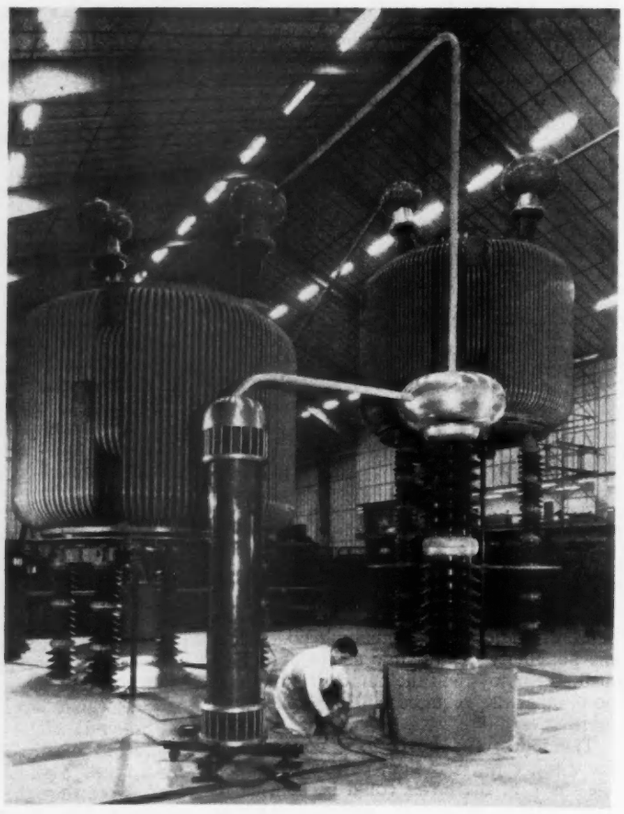


Fig. 2—Nos. 1 and 2 transformer units of 800kV, 50 c/s a.c. testing set. In the foreground are the capacitor stack for control and voltage measurements (right), and standard condenser for power factor measurement (left)

reference, and it is tied to nine earthing points driven into the ground to a depth of approximately 30ft. A separate earthing system is used for earthing all the electrical supplies and the frames of the supply equipment. A comprehensive system of cable trenches covered with chequer plates extends over the floor of the laboratory and on this is superimposed rectangular metal trunking, set flush with the floor surface, for carrying instrumentation cables.

To allow for the observation of corona under conditions of darkness, there are no external windows. Instead, the building is illuminated by twin 80W fluorescent lighting units, arranged in four rows down its length and providing an illumination of 10 to 12 lumens.

On three sides of the laboratory is a 10ft perimeter road, the fourth side being occupied by a number of cable entries which allow cables to be run out and buried in an adjacent field, to simulate working conditions.

Fig. 3—Control room overlooking high-voltage laboratory. There are eight desks in the form of double consoles housing the control and recording circuits

Test Enclosures

Great flexibility in the disposition of test enclosures was an important requirement in the design of the laboratory, so that each major item of test equipment could supply at least two test enclosures. In the final layout at least seven tests can be carried out simultaneously with the equipment provided. The test enclosures, having dimensions in multiples of 10ft, can quickly be built, using standard fencing sections and posts placed in sockets set in the floor on a 10ft grid. Full safety interlock facilities and danger lights are included in each fencing section.

Impulse Testing Equipment

The 3·2MV impulse generator (Fig. 1) is of two-column construction, having sixteen stages of 0·28 microfarad per stage rated at a voltage of 200kV, giving a total stored energy of 89·6kW-seconds from a generator capacity of 0·0175 microfarad. The generator is provided with automatic tripping, ultra-violet-ray gap stabilisation, remote polarity changeover switchgear and a capacitance potential divider. Provision has been made to double the capacitance and, hence, the stored energy of the generator, if required, at a later date. The generator is charged through a moving-coil voltage regulator and oil-immersed metal rectifier set.

A 1280kV impulse generator made by B.I.C.C. is also being provided and will consist of eight stages, 0·32 microfarad per stage, rated at a charging voltage of 160kV, and will deliver a total stored energy of 32·8kW-seconds from a generator capacity of 0·04 microfarad. At present only four stages are completed. The generator is provided with remote polarity changeover switchgear and a resistive potential divider.

Oscillograph recordings from both generators are taken on transient recorders, built to a B.I.C.C. specification and provided with means of automatic programmed control.

A.C. Testing Transformers

The 800kV a.c. test equipment consists of two 400kV transformers, capable of cascade or parallel operation and continuously rated at 2MVA either 400kV or 800kV, with an overload factor of 1·75 for periods of up to one half-hour. They operate with live tanks, which stand on insulating supports, the midpoint of each 400kV winding being connected to its own tank. Three-point support of the transformer tank is provided by arranging the six insulating columns in three pairs with a steel beam across the top of each pair and a ball to take the thrust, at the mid point of each beam, as can be seen from Fig. 2.

The transformers operate in a state of controlled series resonance (with tuning reactors in series with the capacitance of the cable) giving exceptionally wide stable test parameters coupled with good waveform and falling current at breakdown. The tuning reactors are situated in the main transformer tanks and are driven through an insulated shaft which is coupled to a driving and remote indication unit in a small pit under the transformers. The excitation source for the resonant circuit is in the form of two 42kV feed transformers, continuously rated at 100kVA each.

The tuning of the transformers and regulation of the output voltage are so electrically coupled that the two units are kept in step when connected either in series or in parallel. Provision is made to maintain the output voltage of the sets constant and to keep the transformers and load capacitance in resonance by electronic means. Electronic circuits operating from a voltage source derived from capacitance dividers, rather than from the usual current source, are provided for fault detection. This method is used because the current in the transformer winding falls, as opposed to the usual rising characteristic, when the sample under test breaks down. The series resonance circuit maintains the supply power factor near to unity, with a consequent reduction in the load on the supply.

The layout of the two transformers in relation to the building is such that a third transformer can be added at a later date, if required, to extend the testing voltage to 1200kV at 3MVA continuous rating. In association with each transformer there is an oil header tank to take oil expansion from the transformer due to heating under test conditions.

Also installed in the laboratory are two 200kV, 400kVA transformer test sets, which were formerly used at the Prescot laboratory. These transformers are fed from regulators with reactor backing and operate in the parallel mode of resonance. Their control and measurement equipment has been modified and brought up to modern standards.

Another test set which will consist of three 76kV, 50kVA transformers connected in a star bank is being installed; it will give a 132kV, 150kVA three-phase supply. The instrumentation and control of this set follows conventional practice.

Voltage Measurement by Sphere Gap

Very-high-voltage measurements can be made using a 2m sphere gap, which is provided with remote control and indication from the control room. The gap is arranged as a mobile base unit with fixed roof support for the top sphere. Mobile 25cm and 75cm sphere gaps (Fig. 1) are provided for measurement of voltages not requiring the use of the 2m sphere gap.

Control Room

To give full visibility over the whole operational floor area the control room (Fig. 3) for the various items of equipment in the laboratory is at first floor level and protrudes about 5ft into the laboratory. Observation windows of armour-plate glass are provided along the full 80ft of the control room length. Eight control desks, built in the form of double consoles, cater for the control of equipment and all electrical measurements. Each a.c. test transformer is provided with its own Schering bridge and each of the impulse generator desks is equipped with a sealed-tube transient recorder. Next to the control room are wet and dry photographic rooms, offices and an instrument workshop.

Acoustic treatment is applied to the control room to reduce noise and reverberation time to a satisfactory level. Temperature and ventilation are maintained by a system of ducts set behind the ceiling, which provide warm cleaned air. The control room lighting is in the form of double and single 80W fluorescent units.

The ground floor of the control and office block accommodates a switch and regulator room, store for consumable materials, oil processing room and jointing engineers' office accommodation.

Electricity Supply

The electricity supply to the laboratory is taken at 6·6kV through oil circuit breakers to a 750kVA, 6600/433V oil-cooled transformer. Local distribution of supplies is taken through fused isolator panels to individual electrical loads.

A ring main is provided in the laboratory to give services of 415V, 60A, three-phase neutral and earth and three 230V, 13A outlets at fifteen points around the laboratory. The main function of the 60A service is to operate ring-type current-loading transformers and portable oil degasification plant. The lower current services are for small portable tools and similar appliances.

Work in Progress

During a visit to the laboratory last week we were shown some interesting examples of work in progress. Much of the current work is concerned with the contract for the Kariba hydro-electric scheme, Rhodesia. We saw a high-voltage a.c. test on a 330kV sealing end porcelain for which the withstand requirement is 555kV r.m.s. for one minute. In one test area a length of 330kV oil-filled cable installation was undergoing sphere gap calibration in preparation for impulse tests at 85 deg. Cent. as part of the approval tests required for the Kariba contract. Calibration was carried out at 1250kV, enabling the specified withstand level of 1500kV to be extrapolated. In another area a 330kV oil-filled cable loop was being erected in preparation for type approval tests, including power factor and temperature cycling.

Lengths of 330kV oil-filled cable suspended vertically from one of the scaffold structures were being drained of oil and then reimpregnated in preparation for Kariba type approval tests. At Kariba the cable between the generating station and the switching station will be in a vertical shaft. After installation the cable will be drained, flushed with inert gas and then reimpregnated. The practical details have been worked out on a trial installation in a Kent quarry.

Several improvements in 132kV impregnated-pressure-cable joints and terminations are being developed in the laboratory. Among the examples we saw were a sealing end containing a straight pressure equalisation pipe instead of the spiral form at present in use ; nearby an installation was being erected for development testing of an improved design of straight joint.

For 132kV oil-filled cables a new kind of termination, consisting of an epoxy-resin sealing end, is under development for routine test use.

A loop of 25kV, single-phase rubber-insulated cable for railway locomotive pantograph connections was being prepared for d.c., a.c. loading cycle, and impulse tests.

Nearby a loop of 25kV d.c. concentric, mineral-insulated, non-draining cable for use by the United Kingdom Atomic Energy Authority, Harwell, was being prepared for a.c. withstand, d.c., and impulse breakdown tests.

We saw two examples of work on polythene-insulated power cables. In the first, a length of cable was being subjected to a repetitive cycle, being charged to 100kV and then discharged to earth every two seconds. In the second, routine ionisation testing was carried out on a production length of polythene-insulated cable to enable defects in the insulation to be detected and located.

Contractors

The work of building and equipping the high-voltage laboratory was carried out by the following firms :—Main building contractors, James Longley and Co., Ltd.; building consultants, Messrs. W. A. Atkins and Partners; 3·2MV impulse generator and 800kV a.c. test equipment, Ferranti, Ltd.; switchgear and supply transformer, Brush Electrical Engineering Company, Ltd.; regulators for 200kV transformers, Brentford Transformer Company, Ltd.; transient recorders, Sargrove Electronics, Ltd.; capacitors in impulse generators and potential dividers, capacitor division, British Insulated Callender's Cables, Ltd.; lighting, Electrical Installations, Ltd.; cables and wiring, British Insulated Callender's Construction Company, Ltd., and B.I.C.C., Erith works, electrical department.

Ultrasonic Image Camera

An " ultra-sound " (or ultrasonic) image camera which promises to be of considerable use in engineering inspection and in medicine was described in a lecture by Dr. C. N. Smyth, M.A., B.Sc. (Eng.), B.M., B.Ch., M.I.E.E., and Mr. J. F. Sayers,† Grad. I.E.E., at a meeting of the Electronics and Communications Section of the Institution of Electrical Engineers on February 18. The ultra-sound camera is akin to a television camera except that its image-receiving surface is sound-sensitive (piezo-electric) instead of light-sensitive (photo-electric). The camera and viewing equipment described in the following résumé of the lecture were built by the authors, with the support of the R. W. Paul Instrument Fund, in the Physics Department of the Northampton College of Advanced Technology, London.*

WITH the ultra-sound (or ultrasonic) camera described in this lecture, visual studies can be made of the internal structure of objects which are transparent to ultrasonic waves and are immersed in a suitable medium. In its uses this equipment is complementary to X-rays and to ultrasonic pulse-echo inspection methods. It has applications to the non-destructive testing of materials and engineering components and to medical diagnosis.

The principle of the instrument (Fig. 1) is to immerse the object to be examined in a continuous-wave ultra-sound field and to form an ultra-sound image of diffraction pattern on a single piezo-electric plate. This piezo-electric plate is made the end wall or face of a scanning electron tube similar to that of a television camera.

The ultra-sound vibration image falling upon the camera face produces a corresponding alternating piezo-electric voltage distribution, the magnitude of which is read off, point by point, by the scanning electron beam. At each point the camera provides an output current proportional to the incident ultra-sound intensity, which, after amplification, modulates the brightness of a television reproducer scanned in sympathy with the camera.

In the apparatus demonstrated at the lecture the camera face is an uncoated X-cut quartz crystal, 1in in diameter and of half wave resonant thickness at 4 Mc/s. The tube is magnetically deflected and focused and the internal surface of the quartz crystal is scanned, at 50 lines per centimetre, 50 frames per second, to provide cathode-potential stabilisation of the quartz surface.

The ultra-sound " illumination " is switched on for alternate frames only, so that between each there is a change in charge distribution on the quartz and the picture can be reproduced repeatedly and moving objects can be followed. The surface of the quartz becomes negatively charged from the arrival of electrons during positive half-cycles of the alternating piezo-electric voltage and is returned to cathode potential through the arrival of positive ions.

Construction of Camera Tube

The ultra-sound camera is simple to construct, comprising as it does only a 4·5cm diameter glass envelope, fitted at one end with a cathode-ray tube gun and zirconium getter wire and, at the other end, an ion-trap gauze and the quartz-plate " Araldite "-cemented to the glass with an intervening annulus of non-magnetic steel to maintain an orthogonal electric field in the decelerating space.

The " Araldite " cement is cured as the tube is baked for out-gassing. The components secured by " Araldite " are lapped so that very little resin surface is exposed to the vacuum. Tubes made by this technique four years ago still have a satisfactory vacuum.

* University College Hospital Medical School.
† Northampton College of Advanced Technology, London.

Choice of Piezo-Electric Material

The possibility that a single piece of piezo-electric material would, if damped by a liquid, sustain a varying vibration intensity distribution over its surface in sympathy with the driving-force distribution, rather than resonate as a whole, was first suggested by Sokolov. He proposed to use such a transducer with mechanical or electron scanning, but no realistic details of his electron scanning method became available.

The choice of the material for a camera is governed by the following factors : it must be non-porous and strong enough to form the end wall of the vacuum envelope or be suitable for acoustically binding to the end wall. It must withstand temperatures of at least 200 deg. Cent. during the process of tube manufacture. Until recently quartz was the only suitable material. A 2·5cm diameter disc, 0·07cm thick, edge-mounted, has a 50 per cent margin of safety against implosion from atmospheric pressure. Unfortunately, quartz is very anisotropic and the thermal expansion in two directions at right angles differs by as much as 2 : 1. It can only therefore be secured to metal or glass with resilient cements such as epoxy resin. The vapour pressure of the epoxy resins leads to limitations in the design of the camera electron system.

Quartz has a good piezo-electric sensitivity, producing at 4 Mc/s a camera face voltage of 150mV for an incident sound intensity of 1μW per square centimetre. In the absence of interfering effects from the scanning system the sensitivity would be limited by noise at about 10^{-9}W per square centimetre. At these low sound levels there is no danger of damage to biological tissues. Much of the authors' work has been done at about 10^{-6}W per square centimetre.

The *Q*-factor of quartz damped on one surface by a liquid is reduced to about 18, under which conditions there is little loss of image resolving power due to multiple internal reflections. The first interference fringe or halo is more than 20 dB below the main signal. The resolution has been determined both practically and by direct measurement and is about 0·5mm at 4 Mc/s. With thicker crystals working at the third-harmonic mode the resolution is only slightly reduced. Cameras are operated in the resonant or near resonant condition in order to produce strain in the quartz, one surface of which is free.

Removing Negative Charge from Insulating Piezo-Electric Surface

During the scanning frame in which the ultra-sound source is " on " electrons arrive

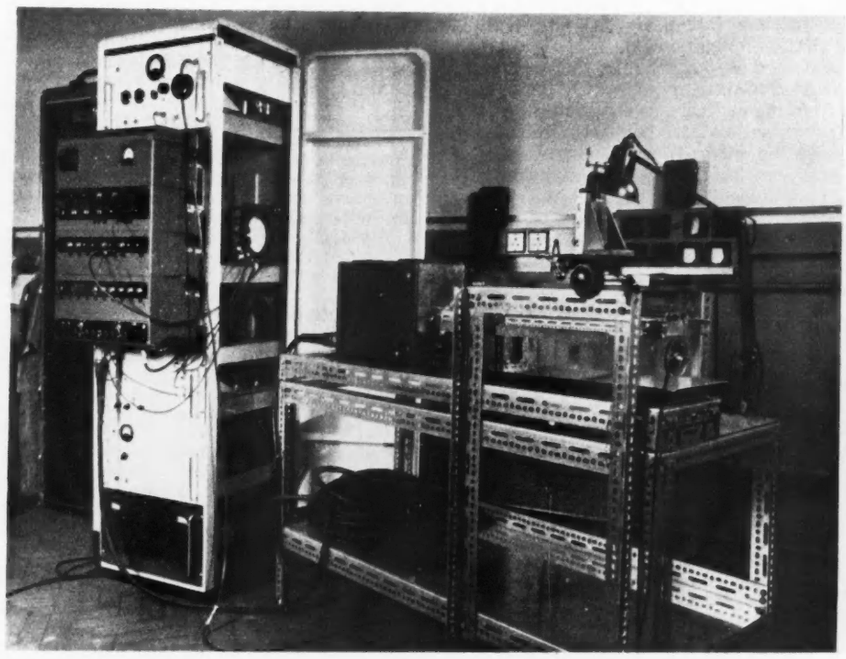


Fig. 1—The ultrasonic camera and inspection tank mounted on a slotted angle trolley. On the right-hand end of the tank is the ultrasonic transducer. The test object and lens can also be seen. To the left of the camera is a cabinet containing the scanning generator

at the insulating surface during positive half-cycles of the piezo-electric alternating potential until the surface is negatively charged to their peak value. The outer surface of the quartz plate rests against a conducting electrode, transparent to sound, and is earthed at sound frequency (4 Mc/s) but not at the output signal range of frequencies (0–2 Mc/s). The current flow to this electrode is the output signal from the camera shown, although the returning gun beam current would be equally suitable. The static charge produced on the quartz must be removed before the camera can again repeat the same picture.

The camera tube contains residual gas at a pressure of about 10^{-6}mm Hg, the scanning beam consists of a mixed pencil of ions and electrons. If an ion-trap mesh is placed about 1cm from the quartz, only ions produced in this space will be able to reach the quartz, and they will be uniformly distributed over the scanned area. The number of electrons greatly exceeds the number of ions. When the surface of the quartz is positively charged it collects negative charge predominantly from the electrons, and when it is negatively charged it collects positively charged ions only. A mixed beam therefore stabilises the surface at cathode potential. To make the times of the charging and discharging frames equal, the beam current is increased during alternate frames in order to provide enough ion current in the time available.

Ion recharging provides a very uniform cathode-potential stabilisation and also greatly simplifies the camera design because no mosaic or other surface treatment is required for the piezo-electric plate surface. Further, a very high vacuum is not required.

Other methods to remove the negative charge are :

(*a*) High-voltage scanning to produce a secondary emission coefficient greater than unity. This leaves the surface very positive, and a further frame scan with a high-current low-voltage beam is necessary to restore the cathode-potential-stabilisation condition before the picture can be repeated.

(*b*) Conducting films. Attempts to produce such films uniformly were not successful, although photo-conducting selenium which would intermittently remove the charge during a brief period of illumination showed promise for further development.

The technique of using photo-emission to remove the charge is not possible in the presence of epoxy-resin vapour, but more recent work using titanium ionisation pumps shows that this may not be an obstacle in the future.

Ultra-Sound Optical System

The instrument has been used only with "Perspex" and "Polystyrene" lenses in water medium. Convergent lenses are biconcave discs. The ones demonstrated are 10cm in diameter and 10cm to 20cm focal length. They have elliptically generated surfaces. They are not bloomed, although the use of plastics loaded with metal powders has been considered for this purpose. Plane-wave sound sources were employed in the demonstration, but some improvement in definition at the expense of sensitivity can be obtained with non-directional illumination. Interference patterns and standing-wave effects can give rise to distortions of the image, and may be reduced by the avoidance of parallel reflecting interfaces, by the use of non-reflecting supports, and by employing frequency-modulated or white (amplified noise) sound for the illumination.

Present Limitations and Possible Future Developments

The camera-sensitive surface is limited in size by its ability to withstand atmospheric pressure. As the tube end is made thicker, the picture resolution decreases and no advantage is gained that lenses with greater magnification could not provide. This is true whether the crystal is supported on metal or not. However, metal is stronger than piezo-electric materials and can be made very thin, but it distorts on evacuation and the authors have not found a correspondingly pliable piezo-electric material which could be made adherent to the metal and yet stand the distortion which would be produced during evacuation of the tube. Modern methods of spraying ceramics offer promise for the future.

So long as cathode-potential stabilisation is employed as the means of signal detection, orthogonal low-voltage magnetic scanning is needed and induction of voltages into the signal circuit limits sensitivity.

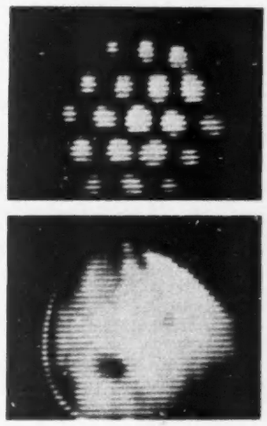
The authors have considered overcoming this latter difficulty by coating the piezo-electric plate with a photo-electric mosaic and scanning with a light pencil instead of an electron beam. With the use of titanium ion pumps the authors have prepared active and permanent photo-electric surfaces in the presence of epoxy-resin vapour, and it is possible that this line of development will come to be used.

Employing secondary-emission stabilisation of the insulating surface (at $\sigma=1$) the piezo-electric charge can be made to modulate the secondary-emission current. In recent months a camera of this kind, continuously pumped, has been described by Zeiss.

Another alternative is to use piezo-electric plates outside a tube with a Charlotte plate window.

Other Kinds of Camera

If sufficient intensity of sound is employed the ultra-sound image may be rendered visible by optical interference or Schlieren methods (Zeiss), by the alignment of aluminium flakes dispersed in oil or by their direct heating effect on a thermionic cathode screen (Pohlman). Suckling has investigated the mechanical scanning method of quartz plates, first suggested by Sokolov, with considerable success.



Figs. 2 and 3—(Upper) Image of perforated zinc sheet produced at 1 Mc/s ; holes at 3mm centres. (Lower) Ultrasonic photograph taken at 4 Mc/s in water bath with "Perspex" lens. The black spot in the white area shows a cavity in a 2in block of aluminium

Some examples of work done with the author's ultrasonic camera are illustrated in the photographs reproduced here. The main purpose of Fig. 2 is to demonstrate the resolution and sensitivity of the instrument ; it shows the image at 1 Mc/s of a perforated zinc sheet having holes at 3mm centres. In Fig. 3 the dark spot in the lighter area represents a cavity in a 2in block of aluminium. Both photographs were taken with a "Perspex" lens in a water bath.

Other demonstrations given by the authors during the recent I.E.E. lecture showed how the instrument could be used to identify defects in welds and bonded materials. Ultrasonic radiation patterns from surface flaws were also shown. An interesting

example of defective bonding consisted of a part of a printed circuit ; the bonding defect was clearly shown by the ultrasonic technique but was not revealed by the normal radiographic examination. The authors also showed several examples of the building up of composite pictures of larger engineering objects and of medical specimens.

It is submitted that, even in its present form, the instrument demonstrates the value of a new technique, and has practical application in the field of non-destructive testing where it is speedier than radiology and sensitive to elastic discontinuities which affect the strength of materials and cannot be revealed except by acoustic means. In comparison with pulse-echo ultrasonic flaw detection it delineates the shape and orientation of flaws and enables their significance to be judged.

On the medical side its practical value has yet to be decided. It avoids the dangers of radiation methods, but larger cameras are necessary before it can find many useful applications. It holds promise for the better inspection of soft body tissues, of masses in the abdomen or breast, for watching the fœtal heart during the strains of labour, and for investigating growths near the radiation-sensitive gonads. Once the instrument becomes available as an industrial tool it may well find further applications.

Fusegear Testing Facilities

WHEN undertaking development of a new range of switch and fusegear, the Revo Electric Company, Ltd., Tipton, Staffs, decided to provide facilities for short-circuit testing from which the design staff could gain important information as work proceeded. In this way it has become possible to submit equipment for independent test and certification at one of the recognised A.S.T.A. stations in the knowledge that all necessary steps to meet the required rating have been taken already.

Special importance was attached to working out a test procedure and designing equipment to give the required programme automatically, so that the product design staff could concentrate on their economic function of improving the end product unhampered by the need to improvise experimental methods. An electronic control system has been devised to initiate in their proper sequence and timing all the steps of the short-circuit test proper, which more commonly are governed by a pendulum or falling weight. The whole project has been planned and carried out entirely within the resources of the Revo Electric Company, Ltd.

The new B.S. 3036, which replaces B.S. 88 for semi-enclosed fuses, calls for three-phase testing, but considerable simplification can be made in auxiliary apparatus and recording instruments if testing is confined to single-phase operation. With the new Revo installation, allowances can be made in evaluating results to give very close reconciliation between single-phase and three-phase performance.

Power for testing is derived from a 600kVA alternator direct-coupled to a machine which was originally the driving motor but has been modified to serve as a dynamic braking generator and flywheel, contributing in the latter capacity a stored mechanical energy of 1050ft-tons. This set was built by Laurence, Scott and Electromotors, Ltd., and was designed originally for welding ships' steel cable, giving an output of 600kVA, continuous rating, at 800V single-phase, 50 c/s. It was found possible to rearrange the winding for 500V output without exceeding permissible values of excitation. The rotor windings of the former motor have been permanently connected to a braking resistor and an exciter set has been installed which supplies 78A at 300V to the stator when a circuit breaker is closed to initiate dynamic braking. By this means it is possible to bring the main set to a standstill in fifteen seconds, whereas without braking it would continue to rotate for some fifteen minutes.

The original alternator exciter, with a rating of 252A at 69V, was retained, and separately mounted alongside the dynamic braking exciter. Both excitation generators are driven by independent 30 h.p. a.c. motors.

A new 130 h.p. a.c. motor was installed and coupled to the 600kVA alternator set by vee-belt drive with a ratio such that the terminal speed of the drive is 750 r.p.m., plus 7 per cent.

Interlocks prevent the alternator from being run up until the braking exciter is in operation. Because of the severe starting conditions imposed by the inertia of the system, the starting arrangements for the alternator driving motor are such that accelerating time is reduced to the minimum. For this purpose, the output from a current transformer in the stator circuit is rectified, compared with a reference voltage and the difference passed through a d.c. amplifier feeding a servo-motor coupled to the liquid resistance starter. The reference voltage is preset, so that throughout the starting cycle the stator current is maintained at maximum permissible overload. On breaking the rotor circuit, the servo-motor automatically returns the liquid resistance to the fully " out " position.

The alternator is connected to the station busbars through a Brush 25MVA oil-immersed circuit breaker fitted with an inverse time over-current relay for backing-up purposes. This breaker can be remotely controlled by a B.T.H. " Thrustor." A bank of twelve 0·25 ohm resistors which can be connected in various groupings and a range of inductors are provided in the test room for setting up to the prospective currents and power factors required for various tests.

An adapted contact breaker mechanism on the end of the alternator shaft can be set by means of an adjustable cam to provide the reference from which the test cycle begins. Separation of the contacts sets an electronic timing circuit in action which causes the " make " switch to close at the desired point on the voltage wave and allows the short-circuit to be maintained for up to 40 cycles. When the switch has dropped out, recovery voltage is maintained through a small h.r.c. fuse provided the fuse under test has successfully cleared the prospective current. The electromagnetic switch assembly was designed and built by the company.

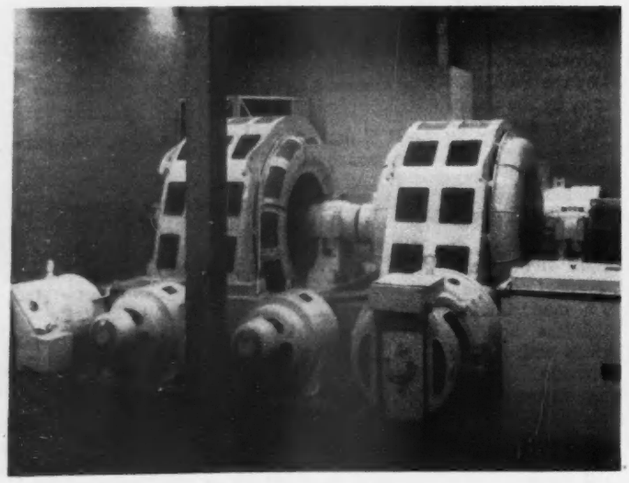
A three-unit control console provides all facilities for operating the machines and conducting tests from one position. The console, shown in the right-hand illustration, was designed and built by the company.

Test current and voltages are displayed on a flat-face double-gun c.r. tube, the oscilloscope having built-in stabilised calibrating voltages for setting up and standardising the " current " amplifier and voltage traces. Oscillograph records are obtained on 35mm film by a camera with drive control interlocked with the circuitry of the control console so that the traces are centralised and the camera drive engaged at the appropriate intervals to minimise the use of film. Dark room facilities are provided so that a developed record may be examined within a few minutes of the actual test.

In conducting a test, the alternator is accelerated to overspeed and its drive motor is then disconnected from the line. This is followed by closing of the main circuit breaker. When the alternator has slowed sufficiently for its frequency to be 50 c/s, the test sequence is initiated and follows through its various steps automatically, as already described. Finally, the alternator is brought to rest by dynamic braking, regulated by controlling the braking exciter output.

So far the equipment has been used only for testing rewirable fuses. At a demonstration on February 18, a 30A fuse was tested at 300A prospective current, 0·5 p.f., and the oscillogram showed the circuit to have been cleared in $11\frac{1}{2}$ cycles.

During the commissioning of the test station, calibration tests were performed up to 12,000A actual current at 500V and at power factors down to 0·5 lagging on non-fusible links over a limited number of cycles. The performance of the whole station under these conditions was extremely satisfactory.



Main alternator (left) and braking generator, with vee-belt drive from 130 h.p. motor (right background). The exciter sets are in the foreground

Test control console, showing starter (left), sequence (centre) and drop-out (right) control units

SHORTER REPORTS

Growing Demand for Water*

CONCLUSIONS AND RECOMMENDATIONS OF CENTRAL ADVISORY WATER COMMITTEE

WE are in no doubt that the rainfall in England and Wales is sufficient to ensure an adequate supply of water to all parts of the country provided that proper means of conservation and distribution are developed to keep pace with the growing demand.

For the near future—up to 1965—we consider that the development schemes prepared by the public water undertakers will enable them to meet demands likely to be made on them. This is not to say that temporary or local shortages will not recur from time to time, quite apart from more general shortages in very dry years (when maximum domestic demand and minimum supply tend to coincide), or that industries seeking new sites will find abundant supplies in any place they care to choose ; moreover, the estimates we have made necessarily assume that in any particular area the trend of consumption will follow approximately its present course, so that any significant deviation not foreseen at the present time could upset the balance. To make provision for full supply in conditions of extreme drought would require expenditure out of all proportion to the benefits obtained, and we have considered it right to proceed on a basis of average demand and ordinary dry year (i.e. not extreme drought) supply.

We have had greater difficulty in assessing future requirements to be met from private sources because we have no complete census of such sources or of the total demand that must be, or is likely to be, met from them. The future pattern of supply will depend to some extent on the facilities offered to industry by public water undertakers, whose estimates make allowance for increasing demands from industry ; but until full information can be gathered—and we comment on this point below—forecasts are bound to be tentative. Nevertheless the estimates that it has been possible to make lead us to believe that in the shorter term the likely increase in demand can be met in each statistical area taken as a whole, although local difficulties may arise, particularly in districts relying on underground sources of supply.

For the more distant future—after 1965—we are of the opinion that there need be no shortage of water in any part of England and Wales provided that :

(i) development schemes are prepared well in advance of demand ;

(ii) The necessary statutory powers and other authorisations are granted ;

(iii) Capital investment is permitted on the requisite scale ;

(iv) The location of industries which require large quantities of water is regulated with the water supply situation in mind.

We emphasise that a satisfactory situation in the future must rest on the readiness of all concerned to regard water as a valuable commodity and to provide money and materials accordingly. We find some difficulty in predicting the requisite scale of investment by public water undertakers but trends suggest that the need is likely to be somewhat higher than the £35,000,000 a year at present-day costs forecast for the next few years because, among other reasons, new sources will be more difficult and costly to develop and water will have to be carried for longer distances.

The estimates make no allowance for water for agricultural irrigation. Development in this field is not at present predictable but it is clear from present trends that irrigation is capable of putting a severe strain on the water resources of those parts of the country least able to stand up to increased demand. The subject requires further investigation which we are now undertaking.

The statistical information at present available on water consumption and resources is incomplete, particularly as regards private supplies. Hydrological surveys by which comprehensive information could be obtained are long and expensive projects and there is little prospect of their being put in hand immediately on a country-wide scale. Nevertheless, in view of the contribution which such surveys could make to the study of supply and demand, we recommend that a start should be made in areas where the expected surplus of supply over demand is lowest.

We recommend that all undertakers should operate an adequate waste prevention service.

Little collated information is available on the economical use of water in industry. With the co-operation of the Federation of British Industries we have initiated an investigation the results of which we hope to give in a later report.

We endorse the findings and recommendations of the Ministry of Health Committee on causes of increase in consumption of water and of the Research Committee of the Institution of Water Engineers on economies in the use of water for sanitation.

* Abstracted from Central Advisory Water Committee: Sub-Committee Report "The Growing Demand for Water," H.M. Stationery Office, price 1s. 3d.

Information on Water Resources*

CONCLUSIONS AND RECOMMENDATIONS OF CENTRAL ADVISORY WATER COMMITTEE

WE consider that there is a need for further investigation into hydrological relationships and for further inquiry into the uses of hydrological information generally, and we recommend that steps be taken to review the work at present being done on hydrological research and to determine how such work should be co-ordinated and what extensions or modifications may be desirable.

We conclude, after studying the representations made to us, that existing or proposed arrangements for the collection and interpretation of information, as described in the report, broadly meet the known need, although we recommend certain extensions of these activities, namely :

(i) The more frequent inspection of rainfall stations ;

(ii) The more accurate recording of snowfall ;

(iii) Further recording in connection with ground water.

Less than one-third of the proposed primary river gauging stations are as yet in operation, however, and we recommend that vigorous action be taken to set up the remainder within the next two to three years.

We also recommend that bodies with a legitimate interest should have access to outline river gauging schemes and that their views as to the siting of gauges should be taken into account at the formative stage.

To facilitate the correlation of hydrological information and thereby enhance the value to users of such information we recommend that data on rainfall, surface water, and ground water should be presented on a common basis of river basin areas.

On Publication.—(*a*) We endorse the planned future content of "British Rainfall" and the Surface Water Year Book.

(*b*) With regard to the quality of surface water, we recommend that river boards should publish lists of places where samples are regularly taken for analysis and also, where reasonably practicable, the analyses taken, or averages and extremes of them.

(*c*) We recommend that the Geological Survey should resume publication of information on ground water.

If there is legislation affecting the artificial recharge of aquifers, we recommend that it should contain provisions requiring that the quantity and quality of water returned to the ground should be measured and that records should be kept and be made available for inspection.

* Abstracted from Central Advisory Water Committee: Sub-Committee Report on "Information on Water Resources." H.M. Stationery Office. Price 1s. 3d.

Minimum-Cost Fighter

THE United States Government has approved the development by the Northrop Corporation, Beverly Hills, California, of the multi-purpose fighter in the family of military aircraft stemming from the T-38 "Talon" tandem trainer : the U.S. Air Force are beginning negotiations for contractual coverage of the development. The fighter is intended particularly for the N.A.T.O. and S.E.A.T.O. nations, being a light-weight aircraft of particular economy of operation and maintenance. The fighter version will have equivalent effectiveness to the Century Series fighters now operational, although its cost will be far lower : it will attain Mach 2 and operate from small and relatively unprepared airfields. Both interceptor and fighter-bomber roles will be encompassed by the single-seater. The two light-weight jet engines are installed in the tail and are virtually as accessible as if podded : the aircraft is so low that much of the servicing can be done without ladders or gantries. The fighter is designated the N-156 F.

The mock-up of the new "N-156F" multi-purpose fighter

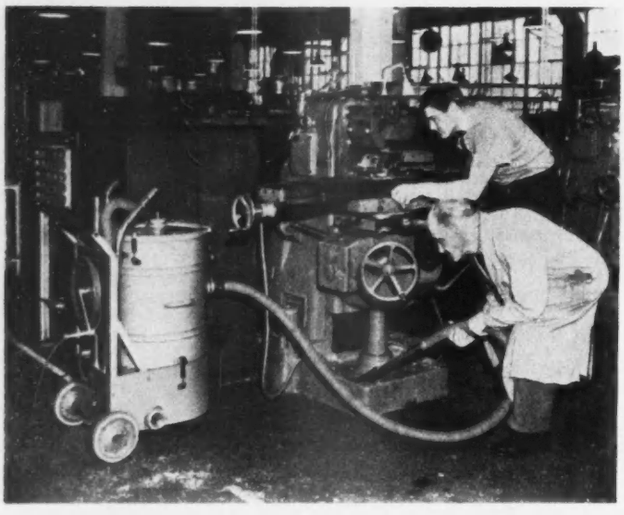
Cleaning and Maintenance Equipment

A FLOOR CARE EXPERIMENTAL CENTRE has been established at the works of Progress (Universal), Ltd., at 590–594, Wandsworth Road, S.W.8. Its object is to provide a testing centre for various floors under everyday conditions. Sections of every standard kind of floor encountered in offices, factories, hospitals, schools and institutions have been laid by twenty of the leading manufacturers. At the centre, they will be subjected to the normal heavy traffic of a general office and factory.

Building managers, caretakers, housekeepers and cleaning contractors will be able to use the centre to examine alternative methods of treatment and maintenance for their own particular floors. These areas of floors will also be available for outside concerns to carry out experiments with different dressings and treatments, and for architects and builders to see the results of various methods of maintenance on any floor which may interest them.

The Floor Care Experimental Centre was opened on Monday last on the occasion of the announcement of the production in the United Kingdom of the Progress "Universal" floor machine, which is now made under licence from the Progress Company of Germany and the Swiss patentees.

Progress (Universal), Ltd., has been granted the rights to export from its U.K. production to all English-speaking countries, including the United States, as well as certain Continental markets. The company has already commenced to export machines to Canada and Africa, and has recently received an order from Australia for £50,000.



Sump drainer cleaning sludge, swarf and oil from machine tool sump

The Progress "Universal" has a circular brush which is given an epicyclic motion at about 2800 r.p.m. when running on a 50-cycle supply. There is little tendency for the machines to drift or pull, and one can be operated single-handed by a woman. Built-in suction eliminates the necessity for presweeping, other than of large litter. The machine has no gears or reduction drive, and it is claimed that 6000 square feet of floor can be polished or buffed per hour, and 4000 square feet scrubbed. The machine is light in weight (50 lb) for everyday duties, but additional weights can be added to bring the total to 1¼ cwt for work such as removing impacted matter, scarifying or sanding. For scrubbing, a tank is clipped on to hold scrubbing fluid.

A special model for hospitals has been developed with a disposable paper filter to minimise cross-infection when cleaning wards. A dry cleaning tool has been developed for the "Universal," which enables floors of most kinds to be damp scrubbed, which is particularly useful for removing obstinate heel marks from modern plastic floors. The "Universal" is powered by a ¼ h.p. induction motor manufactured by Brook Motors.

Progress (Universal), Ltd., also manufactures a sump drainer for draining the sumps of all classes of machine tools. This machine will remove wet or dry solids from inaccessible places, and will drain the sump of the most difficult machine tool in as little as twelve minutes. The unit has a 20 gallons capacity tank into which the contents of a sump are drawn by an impeller driven by a ¾ h.p. motor. A 10ft long, 1½in diameter, reinforced flexible rubber hose, through which the dirty fluid is drawn into the tank, can be fitted with a variety of probe ends to enable the operator to reach into inaccessible places in a sump.

The tank is mounted on a wheeled carriage and its contents can be drained through a large-bore tap. The sump drainer is an adaptation of the Progress "Versatile," the combined wet and dry suction machine, which will dry floors after machine scrubbing. With the insertion of a filter it will deal with all heavy industrial suction cleaning, including boiler flues and chimneys.

High-Speed Flash Tubes

A SERIES of new high-speed cathode-ray flash tubes, which produce a flash of the same order of intensity as a gas-filled electronic flash tube, such as is used in photography, has been announced by the electronics department of Ferranti, Ltd., Gem Mill, Oldham, Lancs. These tubes, known as the CL60 and CL70 series, light up over their whole surface simultaneously, in contrast to the normal behaviour of the cathode-ray tube, and enable 1,000,000 flashes per second to be obtained. It is also possible to produce long flashes, and flashes which contain an internal fine structure consisting of a multiplicity of smaller flashes. The new range is likely to be of value as high-speed stroboscopes and in high-speed photographic work; in the operation of high-speed photo-electric devices requiring short flashes of light, and for time marking on films and in Xerographic processes.

Another possible application is to the measurement of short intervals of time or electrical pulses which occur in a random manner. A tube can be arranged to flash at the beginning and end of a given interval of time or pulse. Alternatively, two different coloured tubes could be used to mark the beginning and the end. Three types of tube are available. The CL60 series are triodes, 3½in in diameter; the CL70 series are miniaturised, 1in in diameter, and the CE1 series are diodes, 6in in diameter. Tubes can be made with phosphors of all colours, including ultra-violet and infra-red. It is also possible to produce "white" light free from the spectral line structure associated with gas discharge lamps and extending over specified spectral ranges.

Elapsed Time Indicators

THE elapsed time indicators manufactured by Cass and Philip, Ltd., Adeyfield, Herts, have now been developed to render them suitable for fitment to plant on which preventive maintenance is carried out on a running time basis. The instruments can be fitted on the plant itself because of their damage-resistant design: the movement is supported by four leaf springs of beryllium copper at intervals of 90 deg. inside a moulded polythene case, in the front of which the glass is sealed by a rubber ring. The polythene case is then mounted in a steel case; the outer case is not part of the electric circuit, there being two insulated terminals on the back of the instrument.

There are alternative information presentations. One has a sweep hand making one revolution an hour over a scale of minutes, and a counter reading up to 9999 hours. The other has the counters only, again to 9999, and a rotating tell-tale shows when the device is running: this instrument runs on for about seven seconds after it is switched off.

It is pointed out that these running time indicators can be fitted to oil engines that have electric oil pressure supervisory gear.

Rapid Process Photography

WE are advised by Polarizers (United Kingdom), Ltd., 186, Acton Lane, Harlesden, London, N.W.10, that Polaroid Land film is now freely available for industrial, commercial and experimental uses.

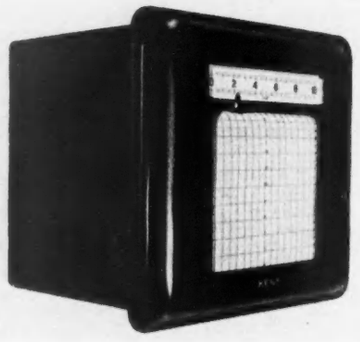
It may be recalled that in the Land process the camera is loaded initially with a pack, including film, chemicals and paper. Processing is performed in the camera immediately after exposing each negative, and takes from one to five minutes depending on the ambient temperature: thus eight exposures can be made in about seven minutes. The finished prints, which are, we are advised, as durable as prints made in the conventional way by illumination, can be either 2¾in by 3¼in or 3¼in by 4¼in. The normal film is panchromatic of A.S.A. 200 (35 deg. Scheiner) but speeds of A.S.A. 400 and A.S.A. 1000 are available.

An import licence is at present required for Polaroid Land cameras in Great Britain. The Series 400 oscilloscope camera of J. Langham Thompson, Ltd., which employs the larger Polaroid film, is available in the normal way.

Strip Chart Indicator-Recorder

AN electronic high-speed strip chart indicator-recorder, developed originally for nuclear and other special applications, has been added to the general industrial range of instrumentation and control devices supplied by George Kent, Ltd., Luton, Beds. This instrument, known as the Mark 3 "Multelec," is available for the precision measurement of millivoltage, and also temperature, in association with thermocouple, resistance thermometer or radiation pyrometer.

Operating speed of the pointer is only two seconds for full-scale travel. A re-designed chart-drive unit permits variation of chart speeds from 1in per hour to 4in per minute. Width of the chart and pen travel is 10in. A high-gain amplifier covers a wide range of a.c. or d.c. input conditions. The amplifier, a sealed-unit servo-motor with built-in tacho-generator, and synchronous converter embodied in the instrument are available for other applications as separate units.



Multi-point instrument with 10in chart width

The Mark 3 "Multelec" is available in single- or multi-point (illustrated) form, with point-cycle times of five, ten or twenty seconds, depending on application, enabling up to sixteen variables consecutively to be measured and recorded with laboratory accuracy. Interchangeable plug-in-unit construction is combined with a high degree of accessibility and reduces the number of spare parts it is necessary to carry.

British Railways Locomotive Orders

A NEW diesel-electric locomotive design in the Type 3 power class (1500–1750 h.p.) is included among orders totalling £16,250,000 announced by the British Transport Commission on Wednesday. This is a C_0–C_0 locomotive of 1750 h.p. to be built by the English Electric Company, Ltd., forty-two of which have been ordered, thirty for the Eastern and twelve for the North Eastern Region of British Railways. Previous Type 3 orders have been for sixty-five locomotives of a B_0–B_0 design rated at 1550 h.p., being built by the Birmingham Railway Carriage and Wagon Company, Ltd., with Sulzer diesel engines and Crompton Parkinson electrical equipment, for service in the Southern Region.

The new English Electric Type 3 locomotive will weigh approximately 108 tons and will be powered by a twelve-cylinder CSVT engine. It will be geared for a maximum speed of 90 m.p.h. Construction of the mechanical parts will be shared between the Vulcan Foundry, Ltd., and Robert Stephenson and Hawthorns, Ltd., both members of the English Electric group of companies. With this order, the English Electric Company, Ltd., becomes the first manufacturer to build locomotives in all the original four British Railways diesel-electric power classifications under the modernisation plan, plus the Type 5 " Deltic " (3300 h.p.) developed by the company as a prototype and now being built for British Railways.

The other contracts are repeat orders for designs already in hand, the largest (over £10,000,000) being for 137 more power equipments for installation in Type 4 locomotives to be built by British Railways at Crewe and Derby. These equipments will be supplied by Crompton Parkinson, Ltd., as main contractor and will incorporate Sulzer 12LDA28 engines and control gear by Allen West, Ltd. Since an earlier contract for ten of these Type 4 power equipments was placed with Crompton Parkinson, Ltd., the continuous output of the 12LDA28 engine has been raised to 2500 h.p. at 750 r.p.m. and a proportion of the new engines will be supplied at this rating, while the remainder will be rated at 2300 h.p. as in the earlier series. The engines will be manufactured in the Barrow works of Vickers-Armstrongs (Engineers), Ltd., and the pressure chargers in the Leavesden works of the de Havilland Engine Company, Ltd. Main generator ratings of 1531kW at an engine output of 2300 h.p. and 1637kW at 2500 h.p. are substantially higher than has been seen in European practice so far for a locomotive with a single power unit.

Repeat orders for complete locomotives to be supplied by contractors comprise seventeen Type 1 800 h.p. B_0–B_0 locomotives from the British Thomson-Houston Company, Ltd., mechanical parts to be built by the Clayton Equipment Company, Ltd., at Hatton, Derby; and thirty Type 1 1000 h.p. B_0–B_0 locomotives from the English Electric Company, Ltd. The foregoing orders total 226 locomotives or power equipments, and bring the total orders placed for main-line diesel locomotives under the modernisation plan to 881. Some 120 of these are now in service and it is hoped that this figure will be increased to some 500 main-line diesel locomotives by the end of the year.

Liquefied Methane Carrier

AT the Canvey Island terminal, Essex, there was berthed last week the " Methane Pioneer," carrying the first cargo of liquid gas to be transported by sea. The ship is owned and operated by British Methane, Ltd., a company formed by the Gas Council of Great Britain and Constock International Methane, Ltd., an American company which has been engaged on research and development work on this project for a considerable time.

In recent years the cost and the shortage of carbonising coal has caused many concerns to install gas-from-oil plants and to consider the use of imported natural gas. Early work on river barges has been used to form the basis of solving the problem of sea transport and has resulted in the conversion of a ship to carry about 2000 tons of liquid natural gas at minus 258 deg. Fah. and at atmospheric pressure, thus enabling it to occupy about one-six-hundredth of the space it occupies as a gas. This quantity of liquid gas is equivalent to 1,000,000 therms and will be transferred to two 1000 tons insulated receiver tanks constructed at the terminal for the North Thames Gas Board, one by Whessoe, Ltd., and the other by the A.P.V. Company, Ltd. Both are 50ft high by 50ft in diameter, and are of double skinned design, the inner skin being of NP5/6 aluminium alloy. The liquid will be converted to gas under pressure and forwarded by pipeline to the Romford works of the Board, where it will be reformed into town gas. This pipeline, which was completed last year, has a diameter of 24in and is designed for a pressure of 275 lb per square inch, at which the capacity is 5,000,000 cubic feet of gas. The pipeline, which was described in THE ENGINEER of February 7, 1958, links Shellhaven refinery with Romford and has an extension to Canvey Island.

The ship is a war-built standard vessel having a waterline length of 320ft by 50ft beam by 39ft 0¾in depth moulded, having a hold capacity of about 227,730 cubic feet bale and arranged with machinery aft. The Nordberg diesel propulsion machinery has been retained but is now supercharged, and the work of reconstructing the ship for its new duties has been the task of the Alabama Dry Dock and Shipbuilding Company, Mobile. Apart from detail modifications, the principal reconstruction has involved the installation of five tanks having a total capacity of 33,000 barrels of liquid methane and the associated refrigeration machinery to maintain the cargo at its correct temperature. These containers are of welded aluminium alloy insulated with 12in of balsa wood and enclosed in a steel protective covering, and provision made for ensuring that the ship's structural steelwork is maintained at normal ambient temperatures. It is understood that the " Methane Pioneer " will make a number of trial runs to assess the commercial possibilities and prove the technical arrangements after which, should the results prove successful, consideration will be given to the construction of larger ships of about 30,000 tons deadweight specially designed for transporting a liquid cargo of 0·42 specific gravity at minus 258 deg. Fah.

Ponders End Lock

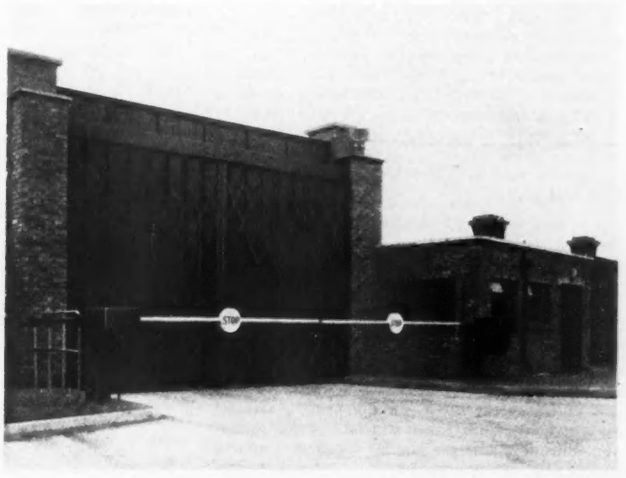
ON February 18, a new lock on the River Lee Navigation at Ponders End was opened by Sir Reginald Kerr, the general manager of British Waterways. The lock is referred to as a " wide " lock, its width being 18½ft as against the 16½ft of the old lock beside it, and it will allow 135-ton Lee barges to travel, for the first time, to the Brimsdown area of Enfield.

The lock is generally of mass concrete construction, and has a length (sill to mitre) of 85ft, an effective width of 18ft 6in, and a depth over the sill of 7½ft. The " head " is about 7ft. The two pairs of mitre gates are power operated, and have by-pass culverts in each wall of the lock.

The movement of a lever in the control cabin on the " island " quay between the new and old locks is all that is necessary for the lock-keeper to move a gate or sluice. Hydraulic power is used, oil being pumped by a 5 h.p. electric motor drive to a maximum working pressure of 1000 lb per square inch. The pump is linked by steel tubing to the gate and sluice mechanisms, each of which is activated by a double-acting piston in a 3in cylinder.

The new lock was designed by Mr. V. H. Tripp, M.I.C.E., divisional engineer of British Waterways' South Eastern Division, who also supervised its construction by the contractor, A. E. Farr, Ltd. The work was completed in twelve months; it involved the excavation of 5000 cubic yards of earth and gravel, the placing of 1600 cubic yards of concrete and the driving of 5500 square feet of steel piles (excluding the cofferdams).

The lock is described as the first major project to be completed of British Waterways' £864,000 scheme for improving the Lee Navigation. Bank protection, improved transit times for navigating locks, and duplication of three other locks, are the main works of this scheme. The present volume of traffic on the 13½-mile section of the Lee between the Thames and Enfield is 2,000,000 tons a year, about a quarter of which is bulk liquids and the rest almost equally divided between coal traffic (to power stations at Hackney and Poplar), and miscellaneous traffic, chiefly timber and non-ferrous metals.



Barrier consisting of two motor-driven booms installed at Clyde Wharf, London, for Silvertown Services Lighterage, Ltd.

Motor-Operated Traffic Barrier

AN electrically-operated traffic barrier has been designed by the Bolton Gate Company, Ltd., Waterloo Street, Bolton, Lancs, for remote control of factory entrances, railway and pedestrian crossings and other locations. The standard Bolton barrier is supported on rolled steel channel posts by means of self-aligning ball races in rigid plummer block housings. The boom, of 3in diameter, 14 S.W.G. aluminium alloy tube, is counterbalanced by cast iron weights. To avoid damage to the mechanism in the event of its being hit by a vehicle, the barrier is designed to swing through a horizontal plane.

An alternative barrier fabricated from 6in by 1in aluminium alloy sections, with 1in by ¼in aluminium alloy under-lattice, is also available. The lattice automatically folds flat as the barrier is raised to give maximum clearance.

Both standard and lattice barriers are powered by a totally-enclosed fan-cooled motor driving through a double worm reduction gear. Drive to the barrier spindle is through an overload clutch coupling which is adjusted to prevent damage should the barrier be obstructed during descent. Limit switches which automatically cut off the motor at each end of travel are incorporated and the whole driven mechanism is housed in a sheet steel case fixed to the main frame.

The barrier is controlled by a push-button reversing starter with built-in isolator which may be operated from inside the gatekeeper's office. In the event of a power failure, the barrier may be raised by hand.

Timber Shell Roofs

SINCE the completion of the shell roof in timber at a new building for the Wilton Royal Carpet Factory near Salisbury, several other timber shell roofs have been started. The

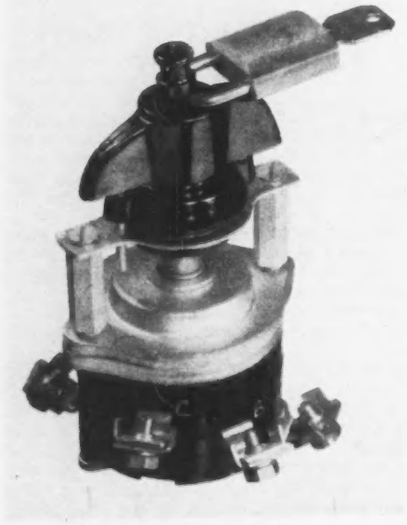
characteristic shape of this type of construction is the hyperbolic paraboloid, a surface of involution which has straight-line generations. The Wilton roof was described fully in our issue of July 26, 1957, page 126.

The most advanced of subsequent projects is the new Sprite's Lane Primary School at Ipswich, the first stage of which is now nearly completed. The assembly hall, classrooms and kitchens (for 240 infants) have timber hyperbolic paraboloid roofs supported on concrete columns, with brick panel walls and timber-framed glazed walls. The rest of the building has timber roofs and load-bearing brick walls. The hyperbolic paraboloids are made up of two layers of tongued and grooved boarding, the bottom layer "stitched," the upper layer laid diagonally, glued for 3ft from the edge and nailed, using galvanised nails. The glued-laminated edge beams are 7in in depth. There are twelve shells in all, ten of 25ft square and two of 20ft square.

Other similar constructions include an egg-packing station near Stowmarket, a school in Scotland and a new roof for the Oxford Road Station, Manchester—part of British Railways' modernisation programme. The last is in the form of a multiple timber conoid. The contractor for the Sprite's Lane School roofs is Wheeler's, Ltd., of Sudbury. The architects are Messrs. Johns, Slater and Haward, of Ipswich, and the engineering design for the shell roofs was carried out by the Timber Development Association, Ltd.

Lockable-Handle Switches

A NEW range of standard four-position rotary switches with handle-locking facilities has been announced by Santon, Ltd., Somerton Works, Newport, Mon. The switches are made in 10/20A and 30/60A ratings for d.c. and a.c. and are arranged for back-of-board mounting. Locking units, of die-cast "Mazak," are available with lever or tee handles and incorporate either conventional built-in cylinder locks or pull-out buttons for external padlocking (as shown in the



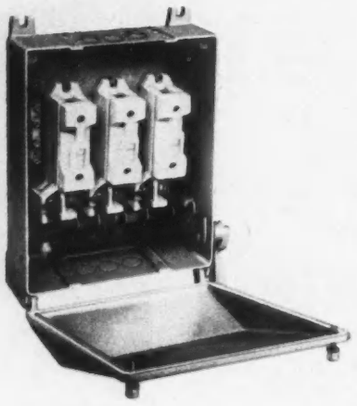
Switch with tee handle and padlock engaging with pull-out locking button

illustration). Both forms of lock may be operative in any or all of the four switch positions as required.

Two kinds of built-in cylinder lock are available, in one of which the key is trapped in the unlocked positions and removable when the switch is locked, while in the second type the key is removable in the locked and unlocked positions. The angular key movements required to operate the lock are 180 deg. and 360 deg. respectively. In each form of cylinder lock switch the total number of lock combinations is 360, of which any sixty-four combinations can be master-keyed. This facility is of assistance if keys are lost and reduces the time before normal operation can be resumed. Locking units are supplied without escutcheon plates so that existing forms of panel marking can be continued.

New Range of Switchfuses

SEVERAL features contributing to ease of installation and maintenance have been embodied in the new range of "Magna" switchfuses now in production by the Revo Electric Company, Ltd., Tipton, Staffs. As can be seen in the illustration, the interior is laid out so as to be free from obstructions near the cable entries, and when entering at the top it is possible to wire straight down to the incoming terminals without passing round the porcelain bases. The switch-bar is removable for wiring purposes by pressing sideways against a spring and withdrawing. This simple procedure can also be followed when it is desired to ensure that the switch cannot be closed while work is proceeding on the circuit it controls.



Switchfuse open, showing unobstructed access for wiring through top cover direct to terminals

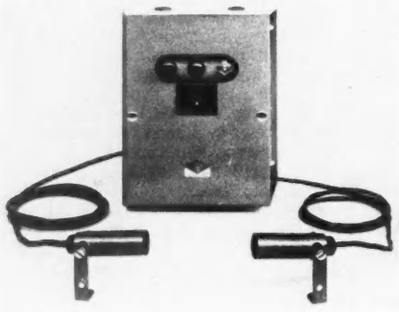
In replacing the bar, the spring registers the moving contacts automatically with the fixed group, and the floating mountings of the former in the bar make them self-aligning. End plates are removable, and are dimensioned so that sealing chambers can be fitted to the same fixing holes if required. Alternative plates to those with the three knockouts shown can be supplied in plain form for drilling by the user, or thickened up for drilling and tapping so that conduit may be screwed directly into the box.

The switch covers hinge on small stub screws so that they can be removed easily if it is desired to check the action of the switch, or to reduce weight when installing one of the larger sizes. The cover is secured in the closed position by captive knurled pins which can be tightened and loosened with the fingers, or by using a screw-driver in the slots provided an extra-tight joint can be made when a switch is installed outdoors. A gasket renders the switches weatherproof. Protection of live terminals is afforded in accordance with British Standard requirements by means of extruded rigid P.V.C. shields which can be clipped on to the porcelain bases or removed with the fingers.

The switchfuses are supplied with rewirable or cartridge fuses. Carriers and bases are made in the company's own ceramic department. The "Magna" range is suitable for 500V and includes 15A, 30A, 60A and 100A ratings in single-pole and neutral, double-pole, triple-pole and triple-pole and neutral forms. It is proposed to extend the range with a series of fused switches with cartridge fuses and of similar construction. These will be of uniform appearance with the present range, so that if used with this series in switchboards a unified design will be maintained.

High-Speed Counter with Photo-Transistors

THE use of transistors in all circuits of a high-speed photo-electric counter now in production by P.A.M., Ltd., Merrow, Guildford, Surrey, enables the device, known as the "Perram" counter, to be operated on a 12V input from a battery or mains supply. Both power sources may be connected simultaneously to separate



Counter unit with remote lamp and detector heads

pairs of terminals, the mains input being transformed and rectified, and serving to keep the battery on floating charge while the counter is operating. In the event of a mains failure, the battery takes over the supply without interruption, and without the need for a changeover relay.

The detecting element consists of photo-transistors, which are most sensitive to red and infra-red light, so that risks of interference by daylight or fluorescent tubes are reduced. Therefore, the standard 12V, 3W lamp in the projector head is underrun, causing its light to be rich in the red and infra-red portion of the spectrum.

The six-digit counter will make up to 2000 counts per minute, operating either on light interruptions or light flashes as short as 1 millisecond.

Aircraft Prospects

IT was announced this week in the House of Commons by the Minister of Supply, Mr. Aubrey Jones, that as a result of an agreement with "the United States authorities," a research programme into the feasibility of the "Swallow" project was to be undertaken in "American Government research facilities," at the R.A.E., and by Vickers-Armstrongs (Aircraft), Ltd. As a result of this research, an aircraft might be constructed in Great Britain. He referred to the "considerable work already done by the Americans in this field": it may be recalled that a Bell design for a vertical-take-off-and-landing jet fighter of about Mach 2 performance has pairs of engines pivotally mounted at the wing tips, a form of engine mounting that is proposed for control purposes on the variable-sweep "Swallow."

The Hawker Siddeley Group announced this week that a provisional order had been placed by Riddle Airlines Inc., Miami, Fla., for the Armstrong Whitworth "Argosy" nose and tail-loading freighter. Riddle Airlines, whose common carriage scheduled services amounted to 26×10^6 ton-miles in the year ended June 30 last—this figure comprising less than half its total cargo traffic, which also includes charter and military contract flying—is the fifth largest all-freight airline in the United States of America. Riddle Airlines is particularly well known for its adoption of the Curtiss-Wright CW-21T or "Commando," one of the earliest pressurised transport aircraft, which at the time of its introduction was the largest of twin-engined aircraft. The "Argosy" is claimed to be "the world's first pressurised turbo-prop freighter-coach," and it is anticipated that Riddle Airlines will be the first civil operator of turbine-powered all-cargo aircraft: the YC-131 Convair liners and T-34 "Globemasiter" conversons were operated by M.A.T.S. We understand that between four and six aircraft are covered by the initial order.

Industrial and Labour Notes

Claim for Shorter Hours

For more than a year there have been periodic discussions between the Engineering and Allied Employers National Federation and the Confederation of Shipbuilding and Engineering Unions over a union claim for a shorter working week in the engineering industry, without loss of pay. The claim was for the establishment of a five-day, forty-hour week. It was rejected last August by the Employers Federation, whose spokesman agreed that whilst it might be the natural hope of everyone that, eventually, factory hours would be reduced, the present time was most inopportune for pressing the application.

Following the rejection, the union confederation decided to submit the claim to the Industrial Disputes Tribunal before that body ceased to function. Last week the Tribunal announced that it had examined the claim but that it did not feel disposed to make any award. Its conclusions were made known in a communication sent to the employers' federation and to the union confederation. This letter agreed that a movement for shorter hours was becoming widespread. But it added that it was difficult for the tribunal to deal with a claim relating to the engineering industry without having regard to the situation in other industries where claims of a similar kind had been made and where, either as the outcome of private negotiations or arbitration proceedings, claims had not been met. After considering these factors, the letter continued, the tribunal did not think it would be appropriate to make an award on the engineering unions' claim as any such award "would have far-reaching consequences." The hope was therefore expressed that the parties concerned would resume in due time their negotiations in regard to working hours and that "in the light of changing circumstances the matter may be given further attention."

Overseas Trade

The January figures of the United Kingdom's overseas trade show the value of exports as £270,100,000 and that of imports as £328,600,000. Re-exports were valued at £9,300,000, with the result that the visible trade gap in January was £49,100,000, a figure £28,000,000 less than in December but £13,000,000 above the monthly rate for the whole of last year.

The Board of Trade points out that the value of exports in January was £4,500,000 more than the December figure. Shipments of machinery, cars and commercial vehicles increased, there was a sharp recovery in exports of wool textiles, and exports of petroleum, chemicals and non-ferrous metals were all higher. But exports of steel fell during January, by £4,000,000, from the improved level of the two preceding months. Deliveries of new ships were low in January and there was the customary seasonal decline in exports of food and drink. The Board of Trade points out also that some of these movements were in line with the changes which have occurred over the last year in the commodity pattern of exports. Between January, 1958, and January, 1959, with the total value of exports 2 per cent down, there were fairly small increases in machinery, aircraft and chemicals, a large increase in the export of non-ferrous metals and a resumption of the export trade in iron and steel scrap. Against those increases, however, there must be set fairly heavy falls in the exports of textiles, coal and coke, steel and metal manufactures, commercial vehicles and ships and boats, and smaller reductions in the exports of food and petroleum. Exports of cars and chassis were much the same in value in January as a year ago, although rather less in number.

The improvement in exports from this country to the non-sterling world, which was apparent in the last quarter of 1958, was substantially maintained in January. Total exports (including re-exports) exceeded £166,000,000, which was 2 per cent above the monthly average for the final quarter of last year. The Board of Trade says that this increase was more than accounted for by a rise of 6½ per cent in exports to O.E.E.C. countries. Shipments from this country to Denmark were two-fifths higher in January and there were increases to Italy, France, Sweden and Switzerland. Exports to Western Germany were unchanged.

The Machine Tool Industry

On Thursday of last week, there was an adjournment debate in the House of Commons on the state of the British machine tool industry. The subject was introduced by Mr. Maurice Edelman (Coventry) who suggested that the machine tool industry had been the first casualty of a "policy of restriction." A simple adjustment towards a policy of expansion, he said, could rehabilitate the industry's present declining fortunes.

Mr. J. K. Vaughan-Morgan, Minister of State, Board of Trade, spoke for the Government. He directed attention to the latest available statistics, which covered the first eleven months of 1958. Compared with the corresponding period of 1957, he said, there had been a fall in machine tool deliveries of 13·6 per cent and a fall in outstanding orders of 28·2 per cent. The difficulties, Mr. Vaughan-Morgan went on, were concentrated around the makers of general purpose machines. Manufacturers of special purpose machine tools still had substantial orders and in the main were employing the same number of workers as in 1956 and 1957. The Minister added his agreement with the view that the best method of stimulating demand for machine tools was to ensure that the overall level of demand for the end products with which they were concerned was kept as high as possible. He went on to say that, even though machine tool exports last year were £3,900,000 lower than in 1957, they were the second highest on record.

Wholesale Prices in 1958

The Board of Trade has stated that wholesale prices last year, both for raw materials and manufactured goods, were more stable than they were in 1957. The falls which occurred throughout 1957 in imported materials prices from the peaks reached in the winter of 1956–57 continued into 1958. On the average, prices of basic materials and fuel used in manufacturing industry were 6 per cent lower last year than in 1957. But, after the first few months of the year, prices of some commodities, and particularly raw foodstuffs, copper, tin and rubber, began to take an upward turn and recovered some of the losses of the preceding year. Prices of textile materials, however, continued to fall throughout 1958.

In a survey of these price movements, the Board of Trade shows that between 1954 and 1957 the prices of manufactured goods were showing year to year increases of over 3 per cent, but between 1957 and 1958 the increase was only about ½ per cent. The engineering industry, it is stated, experienced little change in the level of its material prices last year; iron and steel prices declined slightly in the spring, but the prices of non-ferrous metals were, generally, firmer than in 1957. Prices of engineering products last year were for the most part stable until the wage award in October resulted in some increases in the closing months. Products of the food manufacturing industries rose steadily in price, reflecting the 11 per cent increase during 1958 in the prices of the materials used by those industries. On the other hand, the prices of chemical products and many consumer goods were rather lower at the end of last year than at the beginning.

Chamber of Shipping Report

The report for 1958–59 issued by the Chamber of Shipping of the United Kingdom underlines the growing crisis in this country's shipping apart from that caused by the world wide current depression in seaborne trade. British shipping cannot be taken for granted, the report comments, since this country's relative share of the world tonnage continues to fall while other countries artificially expand their fleets by direct and indirect subsidies and discriminatory clauses. To-day Liberia has the second largest fleet and is challenging Great Britain for first place. Elsewhere many nations are establishing national fleets with complete disregard for economic considerations and existing services.

British shipowners, the report says, have experience of depressed freight markets and are able to face economic storms, but are alarmed at the growth of national fleets which has resulted in there being too much tonnage in the world with more still to come. This position, combined with the triple threat of subsidies, flag discrimination and flags of convenience, it is felt, has put the future of British shipping in jeopardy since our shipping receives no protection of any kind, and has to compete with nationalised, subsidised and non-taxpaying shipping. The initial and investment allowances are appreciated but the former has to be repaid and the latter is only of real benefit when there are profits to set against it. Another difficulty facing shipowners, which is mentioned in the report, is that taxation is now assessed on earnings made in more profitable times; it is felt that more should be done by the Government to help the shipping companies to reinvest a larger share of their earnings made in the good years.

North West Oil Pipeline

After a construction period of slightly over one year, the 390km-long 28in oil pipeline from Wilhelmshaven to Wesseling, south of Cologne, has come into service. Designed for an ultimate capacity of 20,000,000 tons per annum, it serves a group of refineries in the Rhineland and Ruhr districts, including the new Esso refinery at Cologne which recently came on stream. Construction of the pipeline became necessary when it was realised that traffic on the Rhine could no longer by itself cope with the increasing demands for petroleum products. A second 20in pipeline from Rotterdam to Cologne is at present under construction to serve the Shell refinery at Cologne-Godorf and other works, and is due for completion by mid-1960.

THE 390km-long, 28in oil pipeline from Wilhelmshaven to Cologne which began operation on December 29, 1958, is at present the largest in Europe, and serves to supply six refineries and petrochemical plants in the Rhineland and Ruhr districts. The construction and operating company, Nord-West Oelleitung G.m.b.H., Wilhelmshaven, was formed on November 15, 1956, with the participation of B.P. A.G., Hamburg (26·3 per cent ; works to be supplied : Dinslaken refinery), Scholven-Chemie A.G., Gelsenkirchen-Buer (7·7 per cent ; Werk Scholven), Ruhrchemie A.G., Oberhausen (3·7 per cent ; Oberhausen refinery), Purfina Mineralölraffinerie A.G., Mülheim (Ruhr)-Speldorf (8·3 per cent ; Duisberg refinery), Esso A.G., Hamburg (47·2 per cent; Cologne refinery), and Union Rheinische Braunkohlen Kraftstoff A.G., Wesseling (6·8 per cent ; Wesseling plant). The participating works are sited along the pipeline or on spurs in the order given, starting from Wilhelmshaven.

Work at the Wilhelmshaven site started in November, 1957, and on the pipeline itself during February of last year. The first tanker discharged in Wilhelmshaven last November. A total of DM.231 million has been invested, and expansions during the next few years will require a further DM.64,000,000.

Wilhelmshaven Oil Harbour

Installations at Wilhelmshaven include an approximately 650m-long discharge pier (Fig. 1), running parallel with the shore and connected at its northern end with the dyke by a 705m-long bridge, near the end of which a building for the harbour authority has been constructed. A similar pier will be built in a northerly direction during the next few years. The pier is equipped with three discharge points, two of which are arranged on the seaward and one on the landward side. These support 35m high multi-boom hose-crane installations which facilitate making a hosepipe connection between the ship and the pier, which is equipped with discharge lines for crude oil, lines for bunker oil and mains for fresh water. Theoretically up to 6000 cubic metres of crude oil can be discharged hourly at each of the three points, but the actual figure is limited by the pumping capacity of the installed tankers to 800 to 4000 cubic metres. Minimum depth at the pier at low tide is 15m, and average depth is 19m, so that the outer discharge points can be used by supertankers of 100,000 tons deadweight, while the inner discharge point can accept ships of up to 47,000 tons deadweight.

Fig. 1—View of the oil pier at Wilhelmshaven. The shore is some 700m away on the right. The illustration shows two of the three oil discharge booms. Capacity of the pier, which can be used by tankers up to 100,000 tons deadweight, is 18,000 cubic metres per hour : this may later be doubled by lengthening the pier

An area of 1·5 square kilometres was acquired in the Heppenser Groden for a tank farm (Fig. 2). The area is part of a polder constructed in the Jade Bay in the years between the two world wars. The first stage comprises fourteen tanks for crude oil with a capacity of 31,500 cubic metres each. The tanks have a diameter of 55m and a height of 13m, and are equipped with floating roofs. Further tanks will be added later, but the present storage volume is adequate to ensure the continuous operation of the pipeline while at the same time allowing for the separate storage of different grades of oil.

In the first instance, the whole of the pipeline will be served by a single pumping station at Wilhelmshaven. This arrangement will give a throughput of up to 9,000,000 tons per annum. In order to handle later on a throughput of up to 20,000,000 tons per annum, three further pumping stations will be built at Ostenwalde, Ochtrup and Mülheim (Ruhr) ; these stations will therefore be approximately equally spaced along the line at intervals of about 100km. The highest working pressure of the pumps will amount to 60–70 atmospheres. Pumps and engines are placed out of doors and can be heated electrically during standstill periods.

A number of tanks have been provided at Wilhelmshaven for bunker oil for the tankers. This oil is brought by water from the refineries.

The remaining installations include an administration and welfare building, workshops, stores, fire station, laboratory and other services.

Pipeline

For the total length of 390km of the pipeline, about 65,000 tonnes of special steel were used. The pipe is 28in in diameter and the wall thickness ranges from 11·9mm to 7·9mm. The pipes were manufactured by Phoenix-Rheinrohr A.G. and Grossrohrwer Mannesmann-Hoesch. Before

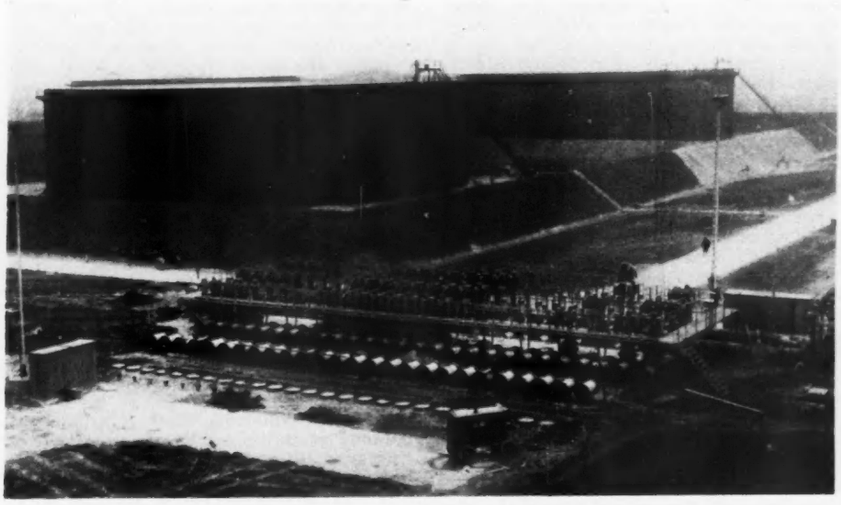


Fig. 2—Some of the crude oil tanks at Wilhelmshaven, with the main distribution point in the foreground

delivery, each pipe was pressure-tested to twice the normal working pressure. For protection of the outside against corrosion, a bitumen-impregnated glass fibre and asbestos wrapping was applied. Over the whole length of line, as well as in the tank farm, additional cathodic protection is provided.

In the layout of the line, particular attention had to be paid to possible interference with water installations and the danger of subsidence in mining areas. Agreements had to be concluded with 2308 owners of land. The use of the land, in particular for agricultural purposes, is undiminished, but no permanent buildings may be erected within a 5m wide strip on either side of the pipe.

The greatest difference in level occurs between Wilhelmshaven and a point south of Mülheim and amounts to about 120m. In laying the pipe, which was given an earth cover of at least 1m thickness, 206 roads and fifty-eight railway lines had to be crossed. These crossings necessitated the placing of the line inside special protective pipes. In addition to many smaller streams and ditches, it was necessary to cross under fifteen rivers and canals, including the Rhine and Ems, the Weser-Ems Canal, and the Lippe lateral canal. These crossings involved the laying of the pipe in special trenches at the bottom of the river or canal bed. Other crossing problems occurred when post office cables, electric cables, and gas or water mains were encountered.

Construction work began by clearing the projected site of fences and trees, after which the topsoil was removed over a width of 6m and down to a depth of 30cm. The pipes, which had a length of 13m, were dumped and bent, if required, by the advance column, working some 5km ahead of the main column. Tracked boom cranes lined up the pipes in lengths of about 90m. After bevelling the edges at 37½ deg., the pipes were internally centred by a hydraulic device, leaving a gap 1·0mm to 1·5mm wide, and welded together. This work was carried out by three specially trained welders, using the downward method, one working inside the pipe and two from the outside. Each joint was gamma-radiographed and the names of the welders marked in code.

The main column excavated the trench at an average rate of 1·80m per minute, using a rotary bucket excavator with a capacity of 250 cubic metres per hour. Minimum cover required was 1m, but this had to be increased in some areas to 1·8m to allow for future deep ploughing (Fig. 3). A 2in dewatering main had to be laid alongside the trench to which 2·5m-long suction lances could be connected at 1m intervals. Pumps were provided for every 30m of drainage line, and were in operation for twenty-four to thirty-six hours in each section.

The prepared pipe lengths were lowered into the trench by two or three boom cranes and connected, with a daily output of about ten lengths. After making good the break in the anti-corrosion coating at the joints, the pipes were covered over and the site restored to its former condition. Sections of the completed work were tested by air pressure at 10 atmospheres, and subsequently by 100 atmospheres of water pressure.

Rhine Crossing

One of the most difficult phases of the work was the crossing of the River Rhine at Km.703 below Leverkusen (Km.320 of the pipeline). The great width of the crossing of approximately 436m made it impossible to follow the usual procedure of prefabricating the pipe length and floating it into position. Instead, it was decided to haul the pipes into place longitudinally. The pipes were welded into two lengths on bogies running on two parallel narrow-gauge tracks on the right bank at right angles to the river. The pipe lengths were connected every 24m by rolled steel sections which spaced them 3·2m apart (Fig. 4). In addition to the normal bitumen protective coating the pipes were surrounded by a 7·5cm thick layer of concrete, which gives additional mechanical protection and served to sink the pipes in the river. The concrete coating was applied by a vacuum method in order to reduce the shuttering period. First, the sections to be supported on the bogies were concreted. After twenty-four hours, the pipes were placed on the bogies, and the remainder of the concrete was applied.

Two seamless gas mains of 145mm bore diameter and 7mm wall thickness were laid at the same time, the pipes being attached to the cross beams of the oil pipeline. Two heads were fitted to the double pipe length and to them the 40mm diameter haulage ropes were attached. In order to equalise the forces, the heads were rigidly connected by beams. Pulleys were used to turn the ropes through a right angle and so allow the tractor which provided the pull to work in a direction along the river bank. A five-rope pulley block was used in order to enable a tractor to operate in the direction of the river bank, at right angles to the pipe, and to provide the total pull required—55 tonnes. The small gauge track sloped down towards the river and just before reaching the water ended in a pit. The bogies rolled into this pit one after the other, disengaging the pipe as they did so, and were at once extracted by crane. The underwater trench had been excavated to a depth of 3·5m in mid-river and was 6m wide, the total excavation amounting to 40,000 cubic metres. After placing the two crossing lengths, they were extended by welding on 220m of pipes at each end. Valves at the ends of the extended sections enable either of the two crossings to be used alternatively. The trench was backfilled with fine gravel, excavated material, and coarse gravel, in three layers. Test pressures for the oil pipe were 6 atmospheres of air and 84 atmospheres of water, and for the gas main 65 atmospheres of air pressure. Pressure tests were carried out, both before and after the pipes had been placed in position. Working pressures at this point in the pipeline are, 10, later 28 atmospheres, while the gas pressure is 40 atmospheres. Hauling the pipes across the river required two hours.

Operation

The oil pipeline is designed for continuous operation. Deliveries for individual refineries amount to several thousand tons at a time ; the batches can be pumped successively without any mechanical separation being required, as the degree of mixing at the interfaces is small. The whole line, including the tank farm, is centrally controlled and operated from the despatcher station at Wilhelmshaven, by means of remote controls operated over rented post office cables. A loss in pressure in any section, indicating a leak, is shown on the control panel and enables the line to be shut down at once. Should the pressure build up excessively, the pumps cut out automatically.

Cleaning of the pipe is carried out by scrapers which are introduced through special locks and driven through the pipe by the oil pressure. American experience shows that the use of a scraper every two weeks is sufficient, except when the oil contains much paraffin in which case scraping has to be done every week.

Esso Cologne Refinery

Two and a half years ago, Cologne was chosen by Esso A.G. as the location for its projected

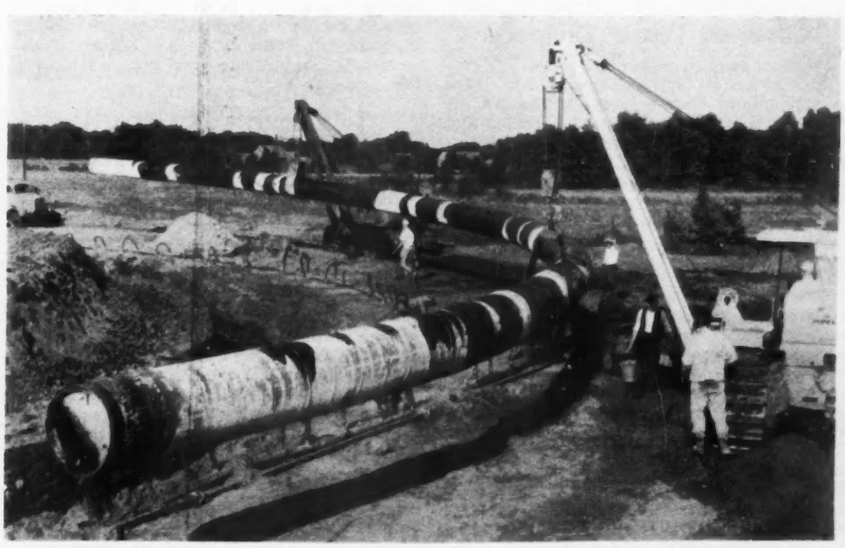


Fig. 3—A right-angle bend is placed into the trench near a pumping station. The dewatering pipes and one drainage pump set are shown

refinery. The site lies in the centre of a vast industrial area, on the banks of the river Rhine, and is served by the new pipeline.

The refinery adds 12,000 tons per day to Germany's refining capacity. Its distillation unit was put on stream in late November, 1958. The second unit, a power-former which is to supply high octane components for the manufacture of gasoline, was put into service about a month ago. A hydrofiner is stated to be ready to perform its function of removing undesirable ingredients from certain products, and a steam cracker for the production of olefines will go into operation this spring. Various other petrochemical plants are to be in operation by midsummer. An asphalt plant will shortly be added.

Although the refinery is located near many industrial plants—Ford is a next door neighbour and Bayer is directly across the river—the area in general is suburban in nature with farmland bordering the refinery on two sides. The total area of the site amounts to 2·5 square kilometres. The refining area itself is located approximately in the centre of the site and is connected to the harbour by means of a road.

The adjoining oil harbour was built by the City of Cologne and will ultimately be able to accommodate ten barges at one time.

While the refinery is designed to supply large quantities of high-grade petroleum products, it will also be able to supply industrial fuels to this part of Western Germany.

The erection of a large number of petrochemical units is an indication of the growing importance of oil refinery operations in meeting demands for the expanding German chemical industry. Land has already been purchased alongside the refinery by chemical companies. One of them is now building a plant to use hydrocarbons from the chemical phase of the refinery's operation. A pipeline to supply concentrated ethylene is being built by Esso A.G. and will be connected with Chemische Werke Hüls about 90km north of Cologne.

Because of the refinery's location steps were taken to make the plant fit into the general suburban area, through landscaping and modern buildings, and by special construction measures such as increasing the height of two tall stacks by 20m to prevent air pollution. Equipment has also been installed to deodorise certain phases of the operation. During construction there was a peak total of 2500 people working in the refinery under the overall supervision of Braun International Corporation, which worked through five German engineering firms. The basic design and engineering were done by Esso Research and Engineering Company.

The DM.250 million project involved the use of 17,500 tons of steel, 15,000 cubic metres of concrete were poured, and a total of fifty-eight tanks for crude oil and intermediate and finished products plus twenty-one tanks for liquid gases have been erected.

Ultrasonic Testing Equipment

We have received particulars of the "Microradar" ultrasonic fault testing equipment made by Réalisations Ultrasoniques, 9, Chaussée de Paris, Meaux (Seine-&-Marne), France, and handled in this country by its subsidiary, Ultrasonic Applications, Ltd., 32, Finsbury Square, London, E.C.2. This equipment operates on the well-known echo principle, but is specially arranged to test thin components. In steel, it is claimed, thicknesses can be measured and faults detected in components or sheets only 0·5mm thick, or 0·3mm in copper, and 0·2mm in plastic.

This is achieved by the use of a transmitter-receiver of extremely small pulse width (0·2 micro-second). The unit is portable (weighing 21 kg) and comprises a power pack with e.h.t. for the cathode-ray tube, h.t. and heater supplies, a cathode-ray tube, time base, synchronisation system, pulse transmitter, and piezo-electric transducers with their coaxial cables.

It is stated that the pulse is transformed into an acoustic semi-oscillation without any parasitic harmonics. The pulse is transmitted through the test piece and reflected at the rear surface, causing two vertical pulses to appear on the C.R.T., i.e. the transmission pulse and the base echo. By varying the speed of the horizontal sweep, the distance between these two can be adjusted to suit the thickness of the material. If the ultrasonic pulse meets a fault, it is partially or totally reflected and the amplitude of the base echo is correspondingly diminished or disappears altogether. Instead there appears a third pulse on the C.R.T., the echo of the flaw, in a position intermediate between the two previous signals and corresponding to the position of the flaw in the test piece.

The hand-operated transducer is of patented design and acts also as receiver of the reflected pulses. It operates by direct contact with the part to be examined, and the coaxial cable joining it to the instrument can be several metres long.

Among the advantages of the instrument are stated to be simplicity of operation, direct reading of distances, and great precision, since by electronic magnification any part of the sweep can be amplified to the full width of 10cm of the cathode-ray tube. Difficulties of interpretation due to such things as harmonics or bad contacts are said to be eliminated.

Where greater speed of testing is required, especially in connection with solid or hollow turned components in the form of bars, the "Sonomatic" bar testing machine, made by the same firm, can be used to advantage. This equipment operates by the "transparency method," in which the attenuation of an ultrasonic beam due to the presence of a fault is measured by the resulting diminution of amplitude on a C.R.T. screen. An ultrasonic beam emitted by a search transmitter unit passes through the layer of water in which the component is immersed, traverses the component itself at a predetermined level and passes out through the water to reach the receiver unit. The received signal is amplified and projected on a C.R.T. In order to obtain a transmitted signal of suitable amplitude, the power of the output signal can be adjusted.

The search unit holder permits the search units to be so adjusted that the ultrasonic beams penetrate into the component above its diameter. This ensures that there will always be one angle of incidence of the beam for which the area of the crack—it is the surface area and not the opening of the lips of the crack which stops the beam—is nearly at right angles to it. The search unit consists of eighteen piezo-electric ceramics of which nine are transmitters and nine receivers. These ceramics are commutated electronically and thereby give a beam rotating at about 100 revolutions per second. The apparatus can also work on the echo principle, in which case the ceramics are both transmitters and receivers at the same time.

The machine comprises a mechanical cabinet containing the liquid tank and electrically driven loading system; the electronic cabinet with C.R.T.; the electronic commutator with the search unit; and a two-pen recorder with two paper speeds.

It is stated that testing can be carried out at a high speed, e.g. for a diameter of 60cm, the feed-through can be up to 10m to 15m per minute, covering the whole component without gaps. Automatic grading into good and bad parts is also possible.

German Atomic Power Project

On January 15, the Gesellschaft für die Entwicklung der Atomkraft in Bayern m.b.H. (Atomkraft Bayern) placed an order with Siemens-Schuckertwerke A.G., Berlin and Erlangen, for the first atomic power project to be definitely placed with a German firm. Work on the project is to commence at once and will take about three years to complete. The power station forms part of the Federal German "500MW Programme." It will have an electrical capacity of 100MW, and operate with natural uranium and a heavy water moderator. Heat generated in the reactor will be abstracted by a primary coolant carried in pipes under pressure, the type of coolant being decided at a later date. The moderator will be at a low temperature and practically at atmospheric pressure. It will be separated from the completely closed primary cooling circuit which will transfer its heat by means of heat exchangers to a secondary circuit working with ordinary water which in turn will operate the steam turbines.

The reactor is to be equipped with a loading machine for the fuel elements. This permits an axial and radial exchange of elements during operation, and enables the elements to be used for a maximum length of time. It is considered that the design is capable of being applied to still larger units.

In addition to this project, Siemens is continuing with the project of a heavy-water moderated and cooled pressure reactor which is stated to be particularly economic in the 50MW to 100MW range.

Congress of Precast Concrete

The Third International Congress of Precast Concrete will be held in Stockholm during the last week in June, 1960. Previous triennial Congresses have been held at Wiesbaden and Brussels. The following themes have been proposed: "Vibration—Its Practical Applications to Precast Concrete," British Cast Concrete Federation, 105, Uxbridge Road, Ealing, London, W.5; "Shrinkage of Concrete," Bundesverband der Betonsteinindustrie, Hausdorfstrasse 191, Bonn, Western Germany; "Large Precast Concrete Elements for Buildings," Dansk Betonvare Industrie, Rosenorns Alle 18, Copenhagen, Denmark; "Industrial Relations and Productivity" Federation National des Fabricants de Produits en Beton, 11, Rue Alfred-Roll, Paris, 17e, France; "Application of Plastics to Concrete" Asociacion Technica de Derivados del Cemento, Balmes 163, Barcelona, Spain. Information and reports on these themes are being invited, and should be sent to the above-mentioned national associations before June 1, 1959.

Furnas Power Station

It is announced by NOHAB (Nydqvist and Holm Aktiebolag), Trollhättan, Sweden, that it has received a large order worth approximately 12,000,000 kronor for turbines from Central Elétricas de Furnas S.A. in Brazil. Furnas Power Station, for which the equipment is intended, is situated on the Rio Grande in the Department of Minas Gerais. The turbines will have a maximum output of approximately 225,000 h.p. under a net head of 98·7m. They will be Francis turbines, similar to those NOHAB has delivered to the Swedish State Power Board for Stornorrfors Power Station. Although they will be somewhat smaller with regard to dimensions, due to the higher head, their output will be larger. It is planned that the first unit will be taken into service during the first half of 1962; ultimately the power station will be provided with eight units.

Dr. Marcel Ballay

Dr. Marcel Ballay, president and managing director of the Centre d'Information du Nickel, Paris, died on February 2, 1959, after a short illness. The loss of such a learned and respected scientist will be regretted in metallurgical and industrial circles in France and the United Kingdom.

Born in 1896, Marcel Ballay entered early upon a career in metallurgy in the laboratory of the de Dion plant, of which he was subsequently appointed head in 1925. In 1928 he joined the Centre d'Information du Nickel as technical manager. He became vice-president in 1950 and president in 1954, succeeding Monsieur Jean Dhavernas. In 1928, Ballay received his diploma as Doctor of Physical Sciences. In 1935 he was promoted to the rank of "Chevalier de la Légion d'Honneur," in recognition of his services as a technical professor, and, in 1955, the rosette of "Officier de la Légion d'Honneur" was conferred upon him for his services to industry and to the teaching profession. He was a member of many learned societies in France and Great Britain. Although the greater part of his activity was devoted to the C.I.N. he was interested in many aspects of metallurgy and there are few fields in this branch of science to which he has not contributed both in research and in teaching.

The American Scene

BY OUR AMERICAN EDITOR

Solar Energy Applications

In recent years considerable progress has been made in putting solar energy to industrial and private use in America. Sunbeams, caught by giant mirrors, can be focused by solar furnaces into heat intense enough to test materials that must withstand supersonic or thermonuclear temperatures. Similarly, solar rays are being converted experimentally into heat for homes, and even an office building, into power for pumps to irrigate desert wastes and for evaporators to distil fresh water from brine. To be sure, such equipment is costly, but less ambitious ideas for using solar heat yet may prove commercially exploitable. In fact, a few products already are on the market which employ the sun's warmth to broil a steak, barbecue a chicken or light a cigarette. Besides working directly with heat from the sun, scientists now also are capturing solar energy by subtler means. Thus, the sunbeam can be converted directly to electrical energy when it strikes the materials selenium or silicon. In the light of this discovery, the armed services have perfected miniature solar-powered radio transmitters of infinite life, and have installed them in soldiers' helmets, as well as in the " Vanguard " satellite. In private industry, solar cells are being tried in oil technology, metallurgical analysis and electronic computing. What is more, in retail shops last year, Christmas shoppers found solar-energised clocks, hearing aids, portable wireless sets and movie and still cameras.

It is in the perfection of techniques for collecting and focusing solar energy that progress lately has been achieved. Most spectacular uses to date have been military. In the large solar furnace recently constructed for the U.S. Army Quartermasters, temperatures of up to 5000 deg. Fah. can be attained quickly and without the attendant disadvantages of contamination and magnetic or electrical interference. Thus, the military can test materials with which to protect troops from nuclear blasts. The furnace has four basic sections located in an area some 125ft long and 40ft wide. The biggest, or " heliostat," is a 40ft high framework, not unlike a huge billboard, on which 355 flat mirrors are mounted to create one vast reflecting surface. The light is passed through a high latticework-surface " attenuator." Nearly 100ft from the heliostat, the sunbeams are gathered in by a third surface, the inside of a spherical " concentrator," containing 180 rectangular, concave mirrors. From here, the highly intensified beam is focused on a 4in test area within the fourth section, or " test chamber." Now the research and development arm of the U.S. Air Force is working on designs for a solar furnace in New Mexico that will dwarf this one, and will be able to concentrate sunlight into temperatures as high as 8000 deg. Fah. A primary use of this new kiln will be to study the effects on metals of extremely rapid temperature changes, simulating the conditions actually confronting missiles aloft.

While urgent military needs dictate the development of such high-temperature furnaces, no such demand, so far, exists to spur commercial applications of solar energy, as heat. The next major development is likely to be the use of solar energy for house heating. At least a half-dozen " solar houses " and one office building have been put up by various groups for test purposes—all in the South-West, except one built by M.I.T. in Massachusetts. In each case, the principle is the same ; sunlight, absorbed by the roof, heats piped water, which then is circulated through the walls. The Association for Applied Solar Energy (A.F.A.S.E.), after running a year-long design contest among architects, built a house of its own at Phoenix, Arizona, recently. The winning design called for overhead louvres, which shade the house in summer, and open at angles in winter to trap the sunlight. The heat is caught by blackened copper tubing, integrated in strips of copper sheet—" tube-in-strip "—and then kept in by an overlay of " Mylar " plastic film. The house itself is a wonder of desert design, walled in on two sides by concrete " screen " masonry and on the other two almost entirely by glass. In the first month it was open to the public, the house became such a tourist mecca that neighbours complained, and county officials had to close it to visitors. But if experience in other solar-heating projects holds true for this one, the high interest in the South-West will express itself in actual demand for the homes.

The aiming of the sun's rays at the consumer market has led straight to another—and very different—collection principle : that of the photo-electric cell. Silicon and selenium cells are now made by a growing group of producers, and are being employed as " solar batteries " in hearing aids, portable wireless sets and solar clocks. However, even more significant at the moment is the solar camera, which makes amateur photography easier than ever before, and cheaper in the long run. In a sense, the camera industry had this principle before its eyes for many years without realising it. The photography light meter, after all, makes use of selenium's response to the sun's visible rays. Two years ago, Bell and Howell put a selenium photo-electric cell into a 16mm movie camera. The cell activates a tiny mercury battery which, in turn, opens or closes the lens aperture. For the first time, this combination enables the amateur movie-maker to follow the action without worrying about his light. Bell and Howell consolidated its lead last year by introducing the first solar-activated 8mm movie camera, at considerably less cost. Here, not even a battery was necessary: the cell itself sets the lens by an electronic signal. By this time, much of the American camera industry got into the picture, and Revere, DeJur Ansco and Keystone came out with similar 8mm camera models. Recently, as a result, Bell and Howell has taken two further steps : it launched patent infringement suits against all three rivals ; then, it reduced the price of its least expensive 8mm model. They have been going like hot cakes. Nor is that all. Consumer research indicates that while one out of five American amateur photographers is a " gadgeteer," who covets the best technique and equipment, the rest are just picture-takers, who want only simplicity and reasonable assurance that the films cannot be ruined by faulty exposure. A solar-controlled still camera, then, would have an even greater potential than the movie cameras. Consequently, at the end of last year Bell and Howell introduced its own still camera, the " Infallible " selling complete with flashgun for 80 dollars. This complex instrument sets the lens opening automatically and requires no light meter and no focusing—all the amateur has to do is to take aim and to push the button.

The photo-electric cells in the " Infallible " are wafers of selenium, a material that responds well to light in the higher bands which make up the visible spectrum ; obviously, selenium is ideal for photographic purposes. However, where more power is required, silicon makes a better cell, since it responds as well to invisible infra-red waves. The development of commercial uses for silicon photo-electric cells originated at the Bell Telephone Laboratories. The Bell System designed the first battery of these crystals—a board about one yard square containing nearly 300 of them, tilted to face the sun—and installed it experimentally in Georgia farm country, where it supplied the only power for nine scattered rural telephones. Up to now, even the highly sensitive silicon cells convert barely 10 per cent of the available sun rays into electricity. Consequently, this kind of energy, too, can be costly. For the most part, then, it is reserved for two types of uses ; those in which relatively little power is needed, and those in which cost is only a minor factor. In the low-power category fall most of to-day's consumer products based on the silicon cells. Their potential generally is limited by high cost and by the fact that, alone among products depending on solar energy, they are expected to perform indoors at least as often as outside in the sun. The solar clock is one example. It will run without attention for a year, and keep perfect time, but only after being exposed to sunlight for a week. Almost in the same class is the " Solaris " hearing aid. Using a 2in strip containing four silicon cells the device is built into the temple bar of a pair of glasses. Again, the wearer of a " Solaris " ought to get out of doors with it every day. The tiny nickel-cadmium battery contained in the hearing aid can be recharged by solar cells in the sunlight, so that between the cells and the battery, the unit will run for up to thirty-six hours on a full charge. The Hoffman solar portable wireless sets, similarly, are " more of a gimmick than not," according to a candid admission by their maker. The sets are made in California, using a cell-pack of twelve solar cells, encased in the handle. Elsewhere in the realm of civilian uses, a Hoffman solar battery is operating in a dollar-bill-changing machine recently installed in New York's Seagram Building. The company also is working with a petroleum company on an application for solar cells in oil-well drilling. Finally, Hoffman is on the verge of announcing the introduction of photo-electric cells for use in electronic computers. Joint experiments with several major computer manufacturers have succeeded in utilising solar energy economically in this expanding field.

For the most part, however, silicon cells are going into military uses, where cost is secondary. Hoffman, for example, is testing

a battery for the U.S. Coast Guard in a lighthouse installation, where the cells supply power for a flashing navigational aid. It is experimenting with a similar system atop a mountain for the U.S. Forest Service. The firm's engineers are aiming for solar batteries that can deliver 2000W ; so far they have reached 500W. The most dramatic use of Hoffman's cells to date is in the " Vanguard." The satellite carries six clusters of eighteen cells each, which provide its radio transmitter with 50 milliwatts of continuous power to keep in contact with stations on earth.

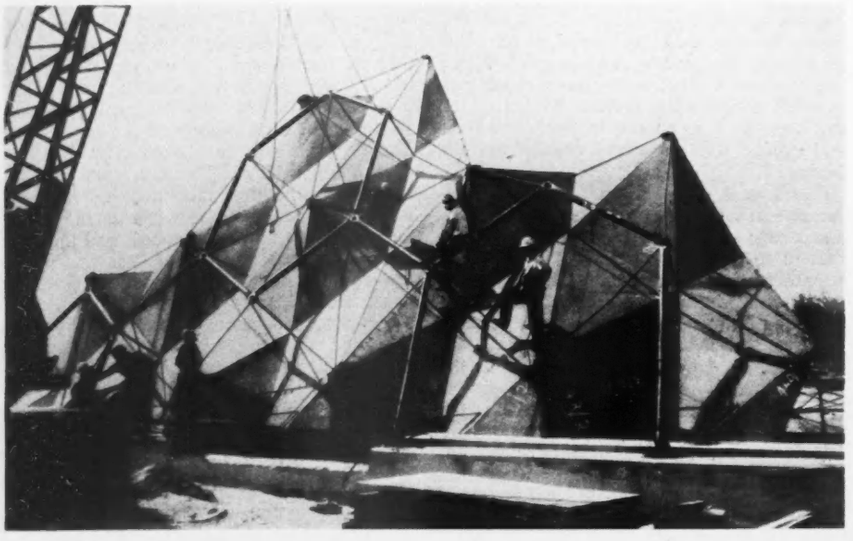
It appears that recent research and development has opened up bright new horizons for many firms engaged in solar experiments. Certainly, nothing is more plentiful than energy from the sun ; a competent authority has estimated that in a single day, enough of it falls on an area 100 miles square in the south-western United States to power all of American industry for an entire year. After centuries of apparent disdain for the sun's potential usefulness, it seems that man finally is achieving a proper respect for this virtually untapped energy resource.

384ft Geodesic Dome

THE accompanying illustrations depict a dome, 384ft in diameter and 120ft high, which is used as a repair shop for railway wagons by the Union Tank Car Company, at Baton Rouge, Louisiana. The dome has no internal supports. Its structural basis was evolved by R. Buckminster Fuller, and it is termed a " geodesic " dome. It consists of 321 hexagonal panels, each formed of eleven-gauge sheet steel, and braced by tubes and rods. The panels are arc welded together. In the first illustration, which shows an early stage in erecting the dome, a typical panel (attached to partial panel shapes at the base of the dome) can be discerned in the left centre, where it is being held in position by the crane prior to welding. The panel is concentric with the hexagon of steel tubes, and its edges are indicated by the temporary clamps which are holding them in position until it is welded on to the adjoining sections. The structure formed from these panels is described as " a three-dimensional unit-cell curved truss." The " truss " has a structural depth of about 4ft. The steel panels, which are described as " involuted," form the weathering surface of the structure and also the inner or tension side of the truss system. The side length of the hexagon of one panel is about 9ft.

The compression members of each of these " panels " or " trusses " are the steel tubes, which are 4in in diameter. The illustration shows the pinned hexagon of these tubes forming the " compression " side of the newly placed panel, with six tie rods radiating from the centre of the panel to the corners of this hexagon. Two further tie rods extend outwards from each of these points, to the corners of the panel, and a further rod, perpendicular to the " plane " of the structure, joins each of them with the corresponding " intersection " point on the steel skin. The rather complicated shape of the panel, each of the six sides of which is V-shaped in elevation, will be apparent from the illustration. Note also the additional tubular members, pinned on to the basic hexagon of tubes, to interlock the panel into the whole structure. These tubes are anchored at ground level through welded steel pinned base plates.

There is over 500 tons of steelwork in the completed dome. No scaffolding was needed to erect it, the only plant being six long-boom cranes. The steel panels were made by manual welding on jigs at the site. The second illustration shows the completed dome, with a structure of similar construction, which is actually a paint tunnel, in the foreground. The main dome contains thirty-six radial repair tracks, and three ingoing and three outgoing tracks. One of the former is for inspection, and one of the latter passes through the paint tunnel. There is a small dome housing a control tower at the centre of the main dome. The cost of the dome was 3,000,000 dollars, and the contractor was the Nichols Construction Company. This information was sent to us by the Lincoln Electric Company, of Cleveland, Ohio.

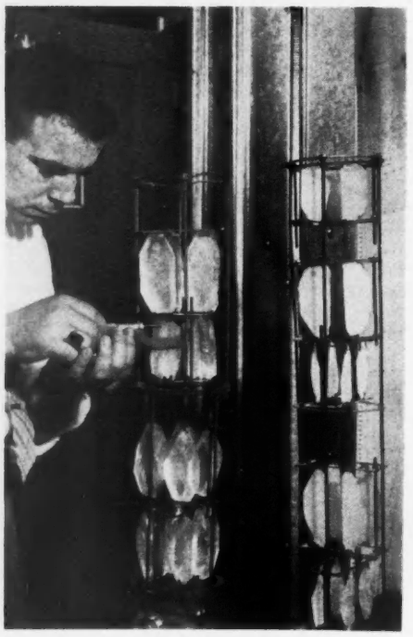


An early stage in erecting the dome, showing a " panel " held in position by a crane prior to welding

The completed dome. Planks are resting on the lower part of the structure

Production of Synthetic Quartz

DETAILS of pilot plant production of synthetic quartz crystals for telephone communication purposes were recently revealed by the Bell Telephone Laboratories. Production facilities based on the new technique are now growing large crystals in limited quantities at the Merri-



Representative series of synthetic quartz crystals grown in Western Electric autoclave

mack Valley Works of the Western Electric Company at North Andover, Massachusetts.

The Bell System is a large user of quartz for filters, oscillators, and frequency standards and has been interested in synthetic quartz processes for some time. This interest has resulted from the increasing difficulty in obtaining large crystals of natural quartz, and from the generally unstable market conditions. Quartz suitable for use in communication devices comes mainly from Brazil, where its mining is carried out on a free-lance basis. An apparent depletion of larger natural quartz crystals has caused critical shortages at times, vividly demonstrated during World War II when it was found necessary to develop other piezo-electric materials, such as ethylenediamine tartrate, as a quartz substitute for use in sonar and communication devices. Synthetic quartz provides a number of advantages over natural quartz in addition to its availability in any quantity and size. Seeds can be cut to provide grown crystals which can be sawed in the most efficient manner. Also, synthetic quartz has natural crystal faces which allow easier orientation of the stock for cutting into crystal units. It has none of the foreign inclusions which usually occur in natural quartz, and it can be produced without either optical or electrical twinning. It is estimated that the greater yield resulting from these improvements is at present at least two and a half times that of natural quartz.

The so-called hydrothermal process has been widely investigated on a laboratory scale for several years, and quartz crystals about $\frac{3}{4}$in square by $1\frac{1}{2}$in long and larger have been grown at the Bell Laboratories. The processing equipment was then scaled up for pilot plant investigation and quartz crystals up to 2in to 3in in each cross section dimension and 5in to 6in long have been grown in this equipment. These operations were not directed towards growing the biggest possible crystals, but towards determining the optimum processing parameters. In the hydrothermal process, a long narrow autoclave mounted vertically is filled with an alkaline solution, usually sodium hydroxide. Small pieces of readily available natural quartz are then placed in the bottom of the vessel to provide the nutrient. Future production will utilise even less costly and more readily available material such as high quality sand as the nutrient. Seed plates cut from either natural quartz, or previously grown synthetic crystals, are hung from a rack in the upper section of the vessel. After sealing, the autoclave is heated to the required temperature, and maintained under a constant temperature differential from bottom to top for the requisite processing time. This period has varied from a week to several weeks, depending on the experiment being performed.

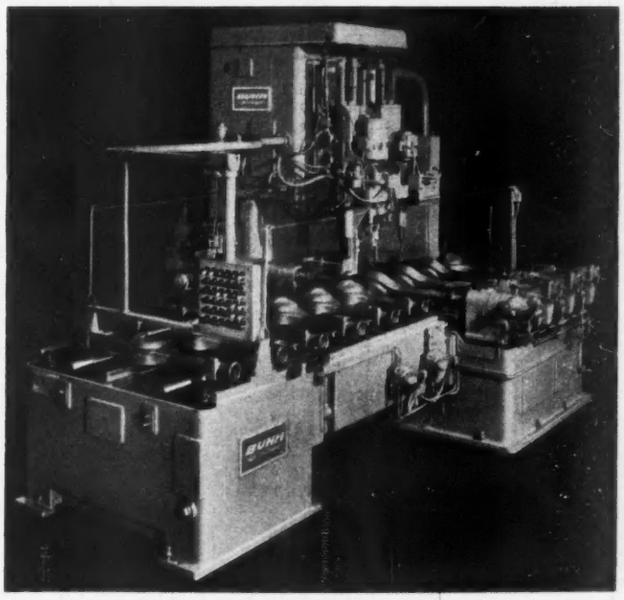
An economical growth rate considerably in excess of 0·060in per day has been achieved. Since growth occurs primarily in one dimension, flat seed plates are used which effectively become thicker but change little in other dimensions. The rate of growth varies with each of a number of conditions, including the temperature differential between nutrient and seed plate area, the alkalinity of the solution, the temperature, and the percentage of fill or pressure. The operation of the hydrothermal process depends on the maintenance of a temperature differential between the nutrient area and the seed plate area. The nutrient dissolves in the hotter lower region and is carried by convection currents to the cooler upper region. The lower temperature here leads to a supersaturated condition in the nutrient solution, which causes the dissolved quartz to re-deposit on to the seed plates in single crystal form.

One of the main problems which appeared in scaling up the pilot plant equipment was that of finding a suitable closure for the autoclaves. The laboratory vessels were simply welded tubes supported by capped, high pressure piping. A repetitive closure was required for the larger autoclaves and a satisfactory closure was developed which gives a tighter seal as the pressure inside builds up. The combination of high temperature and pressure conditions present in this process is believed to be one of the most severe encountered in any process industry at present and gave rise to a number of material selection and equipment design problems.

Transfer Machine Tool

AN automotive company found that it was spending a surprising amount of money each year for new tooling just to drill and finish a vent hole in rear axle housings. The location of the hole and the design of the housing changed each year, and the equipment used one year could not be used the next. This annual cost has now been eliminated by a simple transfer machine designed by the Buhr Machine Tool Company, of Ann Arbor, Michigan. This machine involved a cost of only the retooling bill for one year and can be adjusted easily to drill the hole in any location dictated by present or future part designs. The versatility of this machine does not end there, however. By using a standard coolant base under the load station and by bridging the gap between this base and the main machine base with five idle stations, the transfer machine acts to flush out chips from previous operations and serves as the transferring device between the previous trunnion machine operations and the drilling operations. In addition, a compound movement permits drilled holes to be deburred both top and bottom with the same tool bit, using the same hydraulic unit that feeds the drill in the adjacent station.

The operator on the trunnion machines unloads an in-process housing from one of the trunnions and deposits it in the load station of the ten-station Buhr transfer machine. The part is placed on adjustable, notched rails that run the length of the transfer machine. These rails can take parts varying as much as 8in in length—either 4in longer or shorter than the current model part. Once a part is in the load station, the machine takes over. While still in the load station, coolant is introduced under pressure from both ends. Chips are flushed toward the centre and out because the normal position of the part is with the open face of the "banjo" down. The parts have a chance to drip dry during travel through the five idle stations and all coolant flows back to the coolant base. The workpieces move in steps through the five idle stations. At station 7, the housing is rotated to the correct angle and a $\frac{7}{16}$in diameter hole is drilled at a cutting speed of 65ft per minute with a feed of 4·5in per minute. In station 8 both the inside and the outside of the hole are deburred. The hole is tapped in station 9. Housings are manually unloaded from station 10 at a rate of about 180 pieces per hour at 80 per cent efficiency.



Buhr transfer machine tool for drilling and finishing vent holes in rear axle housings

The workpieces move progressively through the ten stations. Fingers on twin rotating transfer bars catch each part, pull it up out of the vees in the rails and slide it forward into the next notch. The housings are prevented from rotating, while being indexed, by a guide strip down the middle of the machine that contacts the "banjo" if the workpiece tends to turn. The parts are roughly located in the three working stations by the vees in the rails. Accurate location is accomplished by retracting plugs that contact the bearing bores at each end of the housing. After each index of the transfer bars, the guide strip under the working stations is lowered so that the housings can be rotated to the proper angle. Rotation is by means of revolving radial locators that engage a hole in the workpiece flange. The retracting plug units can be adjusted linearly to accommodate changes in housing length, and the radial locators can be adjusted for different angles of rotation. The tooling to drill, chamfer and tap the hole is carried on two hydraulic feed units mounted on a single-vertical column. Tools for the drilling and deburring stations are both carried on a single feed unit and the tapping head for the third work station is on the other. Basically, the standard cycle for both heads is: rapid downward approach, feed, positive stop and automatic high-speed reverse. A compound movement, however, enables both top and bottom edges of the drilled hole to be deburred in one station using the same tool head that feeds the drill in the adjacent station.

While the feed unit descends at a constant drilling feed, a hydraulic cylinder varies the feed rate and direction of the deburring spindle relative to the feed unit. During the first part of the down-feed of the head, the control cylinder moves the deburring tool upward at a rate somewhat less than the down-feed of the head. The difference in the rates is the effective feed of the deburring tool into the work. The spring-loaded deburring blade moves in and out of the deburring tool as it is traversed through the drilled hole. The hydraulic cylinder then feeds upward to give another effective feed rate for deburring the lower edge of the hole. All this is accomplished during the downward stroke of the drill head. By using a single feed unit for two operations and the compound movement for the chamfering tool, it was possible to reduce the initial cost of the set-up while equalising the cycle time of the drilling and chamfering stations. Tapping of the drilled and chamfered hole in the third station, of course, takes less time than drilling. At the completion of the work cycle, the three parts in the working stations are rotated back to normal position, the guide strip is elevated under them, the plugs are retracted and the parts are indexed along by the transfer bars. All of the locating mechanisms, feed rates and tool locations are adjustable to meet requirements. All rotational locations, in both directions, are set by adjustable positive stops.

Personal and Business

Appointments

MR. P. M. MARLOW has been appointed a director of Baker Perkins (Exports), Ltd.

MR. L. G. NORTHFIELD has been appointed publicity manager of Efco, Ltd.

MR. V. J. GARNER has been appointed sales manager of F. E. Weatherill, Ltd.

MR. IAN CAMPBELL-BRUCE has been appointed sales director of Muzicord (Sales), Ltd.

MR. GEORGE L. MITCHELL, M.I.Mech.E., has been appointed a director of Hills Plant, Ltd.

MR. A. E. MORTON has been appointed sales promotion manager of the Matbro Group of Companies.

VICKERS, Ltd., announces that Major-General A. E. Walford has been elected chairman of the board of directors of Canadian Vickers, Ltd.

MR. JAMES D. FURSE has been appointed manager of the refrigeration department of W. J. Furse and Co., Ltd., following the death of Mr. John French.

MR. PETER ALSOP has joined Technograph Electronic Products, Ltd., and will be responsible for the technical sales division in the computer, guided weapons and airborne equipment fields.

MR. W. J. G. HAWKINS, M.I.N.A., has been appointed principal sea transport officer with effect from April 1, in succession to Mr. H. H. Bath, who is retiring from the Marine Survey Service.

MR. P. G. MALINS has been appointed manager of the Midland Region of the British Institute of Management in succession to Mr. B. W. Vigrass, who is moving to B.I.M. headquarters in London as overseas and regional manager.

HOWARDS OF ILFORD, Ltd., announces that Mr. E. W. M. Fawcett, technical director, and Mr. H. P. P. Hodgkins, commercial director, have been appointed to the board of the parent company, Howards and Sons, Ltd.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION has announced that Mr. L. J. Dunnett has been appointed permanent secretary to the Ministry in succession to Sir Gilmour Jenkins, who will retire from the public service on March 31.

THE NEW ZEALAND SHIPPING COMPANY announces that Mr. J. P. R. Williams has been appointed engineer commodore of the combined New Zealand Shipping and Federal Steam Navigation Companies Fleets in succession to Mr. A. C. Munro.

BRITISH-BROWN-BOVERI, Ltd., announces that Mr. R. L. Thomas has been promoted to general manager, following the death of Mr. H. Oswald, managing director. Mr. R. H. Coates, A.M.I.E.E., manager of the electrical section will act as his deputy.

MR. ALBERT WHITFIELD has been appointed general manager of Widnes Foundry and Engineering Company, Ltd. Mr. Ralph Credland, joint managing director, has retired from active duties. He will remain on the board of directors in a consultative capacity.

CENTRAL ELECTRICITY GENERATING BOARD has announced the appointment of Mr. E. V. Hardaker, A.M.I.E.E., as divisional electrical engineer, Midlands and East Midlands Region. Mr. E. M. Packham has been appointed secretary, and Mr. H. Marriott, accountant, of the Eastern and South Eastern Region.

HEAD WRIGHTSON AND CO., Ltd., announces the following appointments as directors of its subsidiary companies : Head Wrightson Steel Foundries, Ltd., Mr. George Taylor and Mr. John D. Eccles ; Head Wrightson Colliery Engineering, Ltd., Mr. Roger B. W. Bolland ; Head Wrightson Stockton Forge, Ltd., Mr. Richard O'Brien.

ANGLO GREAT LAKES CORPORATION, Ltd., an associated company of C. A. Parsons and Co., Ltd., has announced the following appointments : Mr. H. H. Mullens, a director; to be chairman in succession to the late Sir Claude Gibb ; Mr. H. B. Topham, also a director, to be general manager and Mr. D. P. Walton, secretary, to be a director of the company.

RUSTON AND HORNSBY, Ltd., has announced the following internal appointments, which have been brought about by re-arrangements in the company's engineering departments : P. L. Johnson, A.M.I.Mech.E., manager, technical services ; J. K. Bellamy, A.M.I.Mech.E., engineer-in-charge, small engines ; L. H. Milsom, M.I.Prod.E., assistant chief engineer, current engines ; A. M. Porkess, A.M.I.Mech.E., assistant chief engineer, medium speed engines ; L. Stubbs, A.M.I.Mech.E., engineer-in-charge, locomotives and gears ; H. Bayes, A.I.Mar.E., engineer-in-charge, marine applications.

THE BRITISH ALUMINIUM COMPANY, Ltd., states that following upon the change of control of the British Aluminium Company, Ltd., Lord Portal and Mr. Geoffrey Cunliffe, chairman and deputy chairman respectively, have left the boards of that company and all its subsidiary and associated companies. Sir Ivan A. R. Stedeford has been elected a director and chairman of the board of the British Aluminium Company, Ltd., and Mr. Richard S. Reynolds has been elected a director. The following staff changes have been made at the company's rolling mills : Mr. J. A. Richmond has been appointed deputy manager at Falkirk with effect from July 1, 1959, and has been nominated to succeed Mr. Field as manager at Falkirk when the latter retires on January 23, 1960. Mr. T. D. Rees has been appointed deputy manager at Latchford with effect from May 1, 1959. Mr. R. L. C. McDonald has been appointed assistant manager at Warrington with effect from March 1, 1959. Mr. F. C. Foskett has been appointed chief production superintendent at Milton with effect from March 1, 1959. Mr. N. MacDonald has been appointed deputy chief production superintendent at Milton with effect from March 1, 1959, and Mr. D. Lowe has been appointed superintendent of the experimental department at Milton with effect from March 1, 1959.

Business Announcements

MARTONAIR, Ltd., states that it has appointed Notz and Co., A.G. Murtenstrasse 65, Biel-Bienne, 1, Switzerland (telephone, 032-2-55-22) as its agent in Switzerland.

SIMMONDS AEROCESSORIES, Ltd., has announced the formation in Belgium of Simmonds Aerocessories (Belgium) S.A., 25, rue Faider, Brussels, as a subsidiary company. Mr. George Harms has been appointed manager of the new company.

RACAL ENGINEERING, Ltd., Western Road, Bracknell, Berkshire, announces that its instrument division has been formed into a new company, Racal Instruments, Ltd. Mr. J. H. Head has been appointed director and general manager of the new company.

SERVOMEX CONTROLS, Ltd., has concluded an agreement with Feedback, Ltd., whereby Servomex will manufacture and market Feedback designs. Mr. R. C. Steel, chairman and managing director of Servomex Controls, Ltd., has been elected to the board of Feedback, Ltd.

THE YALE AND TOWNE MANUFACTURING COMPANY has opened a new service depot at Wilson Place, Nerston Industrial Estate, East Kilbride, Lanarkshire (telephone, East Kilbride 20241). The depot, besides stocking service parts for Yale trucks, has facilities for overhauls and repairs.

CONCRETE, Ltd., 16, Northumberland Avenue, London, W.C.2, states that, completing the policy of decentralisation, the Bison Works at Lichfield and Hounslow have been formed into separate companies. The name of the former is Concrete (Midlands), Ltd., and the latter, Concrete (Southern), Ltd.

D. NAPIER AND SON, Ltd., has formed a Canadian subsidiary, D. Napier and Son (Canada), Ltd., 4104, St. Catherine Street West, Montreal (telephone, Wellington 7-9383). The directors of the new company are Mr. H. Sammons, M.I.Mech.E., president ; Mr. L. A. Sanson, executive vice-president ; Mr. S. M. Finlayson, Mr. J. C. K. Shipp and Mr. H. B. Style, A.M.I.E.E.

TECALEMIT, Ltd., Plymouth, Devon, states that it has purchased half of the ordinary shares in British Filters, Ltd., Maidenhead. Mr. S. G. Gates, chairman, and Mr. P. R. Scutt, managing director of Tecalemit, Ltd., will join the board of British Filters. Mr. T. E. Worth, M.I.Mech.E., chairman and technical director, will continue in that capacity, together with Mr. Nigel J. Bennett, who will continue as managing director.

SOUTHERN INSTRUMENTS, Ltd., Frimley Road, Camberley, Surrey, has announced the formation of an analytical instruments department which will sell equipment designed and manufactured within the company, and also sell, and in some cases manufacture, equipment of outside design. Mr. W. B. Horner has been appointed general manager of the analytical department, and will be assisted by Mr. G. B. Thorpe and Mr. J. Hetman on applications research.

WILLIAM TOWNSEN AND SONS, Ltd., announces that it has purchased a portion of the business William Ryder, Ltd., Beehive Works, Bolton. For the time being it is the company's intention to carry on under the title of William Townsen and Sons, Ltd., Successors to William Ryder, Ltd., but a new company is to be formed in the early future, to take over the business.

THE HAWKER SIDDELEY GROUP has announced the formation of a new holding company, Hawker Siddeley Australia Pty., Ltd., to manage all the Group activities (except aircraft) in Australia. These activities are in the hands of an existing company Hawksley Australia Pty., Ltd., and a new company Hawker Siddeley Brush Pty., Ltd., which has replaced Brush Group (Australia), Pty, Ltd. Mr. W. S. Warner will be chairman and Mr. James S. Samson, deputy chairman and managing director of the new company.

Contracts

RUSTYFA, Ltd., the British consortium formed for the purpose of supplying plant and equipment for a tyre factory now being built in the Ukraine, has received a further order valued at more than £1,000,000. This latest order is mainly for rubber processing machinery to be supplied by David Bridge and Co., Ltd., and Francis Shaw and Co., Ltd., and for conveying equipment which is to be made by G. W. King, Ltd.

MOBIL OIL COMPANY, Ltd., has announced the construction of a new ocean-fed terminal, costing over £1,000,000, at Ellesmere Port, Cheshire. The terminal is situated 2¼ miles from the Queen Elizabeth II oil dock at the entrance to the Manchester Ship Canal. John Laing and Son, Ltd., is the main contractor and The H. K. Ferguson Company of Great Britain, Ltd., is responsible for the mechanical and electrical work.

COSTAIN (WEST AFRICA), Ltd., has been awarded a contract valued at more than £200,000 to build an extension to the Oji River power station for the Electricity Corporation of Nigeria. The work is expected to be completed by the early summer of 1960. A second 10MW set is to be installed, and the civil engineering extension will provide accommodation for a further set. The consulting civil engineers are Messrs. Coode and Partners, and the electrical and mechanical consultants are Messrs. Preece, Cardew and Rider.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., has received an order from the London Transport Executive for 350 electro-pneumatic camshaft control equipments for Central Line tube trains. This brings the total number of equipments of this type supplied or on order from B.T.H. to 2226 since the first order was placed for the 1938 tube stock. The value of the present order is approximately £1,250,000. Deliveries are about to begin of 504 camshaft equipments ordered previously for new stock on the Piccadilly and Metropolitan lines.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., has been awarded contracts from the Norwegian P.T.T. Administration and the Royal Board of Swedish Communications for a combined multi-channel radio-telephone and television link between Oslo and Karlstad. A further section, carrying multi-channel radio-telephony only, is to be installed in Sweden between Karlstad and Arvika. This installation represents the first order received for the new Marconi HM500 (terminal) and HM550 (repeater) wide-band multi-channel equipments employing an all-travelling wave system and operating in the 4000 Mc/s band. The system is expected to be in operation by May, 1960.

THE ENGLISH ELECTRIC COMPANY, Ltd., and SIEMENS-SCHUCKERTWERKE of Erlangen, Germany, are to carry out a large electric power programme in the Sudan, according to an agreement signed between the Sudan Government and a consortium of the two companies named. The new power programme involves three main schemes : first, a hydro-electric station with two 7500kW water turbine alternator sets will be built at the existing dam at Sennar, on the Blue Nile ; secondly, the Burri Power Station in Khartoum will be extended to include a new 10,000kW steam turbo generating set ; and thirdly, an overhead transmission line will connect Sennar with Khartoum, with intermediate substations at Wad Medani and Hassa Heissa. The total value of the works is over £4,000,000 and the work will begin immediately. The plant and equipment supplied by English Electric will be manufactured at the company's Stafford, Rugby and Liverpool works.

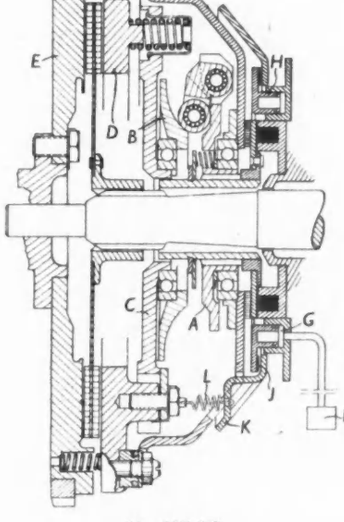
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings, unless otherwise stated. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery La., W.C.2, 3s. 6d. each.

MOTOR VEHICLES

807,477. August 22, 1956.—CENTRIFUGAL CLUTCHES, Societe Anonyme Francaise du Ferodo, 64, Avenue de la Grande Armee, Paris, 17, Seine, France.

According to the invention there is provided in a centrifugal motor vehicle clutch an additional externally actuated control for modifying, during operation, the disengaging force. More particularly this resilient force is increased upon operation of the choke or for starting purposes on an exceptionally steep gradient and is lowered for the purpose of prolonging the braking action of the engine in the region of lower speeds. The drawing shows a longitudinal section through a centrifugal clutch, to which the invention has been applied, the clutch being in the position corresponding to the throttled or idle condition of the engine. In this design of clutch for



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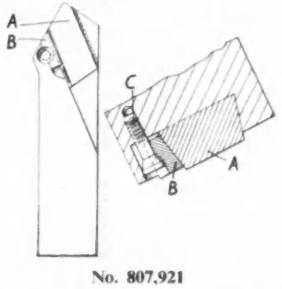
motor vehicles a weight head carrier may be coupled at will with the engine shaft for the purpose of engagement or immobilised by an electromagnet to release the clutch. In a clutch of this nature, the assembly is such that when the weight head carrier *A* rotates with the engine throttled down, the centrifugally developed axial force on the cam *B* and the plates *C* and *D* is compensated by an opposing force exercised by the springs, which hold the plate *D* away from the flywheel *E*. The preconstraint exercised by the springs develops over the entire range of normal operation of the engine a constant disengaging force deducted from the engaging force resulting from the centrifugal force itself. It is, therefore, above idle engine speeds that a torque becomes transmissible, this torque increasing substantially at the normal running speed of the engine. The position is not the same if the choke of the vehicle is operated by the driver or if, when the vehicle is furnished with an automatic choke, the temperature is such that the choke is actuated, because the idle speed of the engine is then increased to become a choke fast idle speed and frequently causes an abrupt engagement of the clutch. According to the invention provision is made for a second method of operation of the clutch in which the force of the springs is modified by a control means connected to, and thus responsive to, the position of the choke, in such a way that the conditions of clutch disengagement with choke become substantially identical with those without choke. By these means the depression chamber *F* of the choke is connected by a pipe to an annular control chamber *G* carried by the fixed frame of the clutch. In this chamber there is an annular plunger *H* with a lightly frictional peripheral portion *J*, which co-operates with a member *K* connected by springs *L* with the pressure plate *D*. When the choke is inoperative, there is no appreciable depression in *F*, and the plunger is not subjected to any suctional effect. The member *K* is not moved and conditions prevail exactly as in the case of normal running in which declutching is effected when the engine is idling. If the choke is actuated, the depression brought about in *F* applies suction to the plunger, and moves the member *K* towards the rear. The springs *L* add their action to that of the main springs to retain the pressure plate, thus counteracting the effect of the force produced by the weight heads. So long as the engine rotates in throttled condition with the speed increase due solely to the choke, i.e. with no pressure applied to the accelerator, the axial force produced by the weight heads is overcome by the springs *L* calibrated accordingly, and adding their action to that of the main springs. When the accelerator is depressed, the pressure of the roller elements preponderates and engagement of the clutch is brought about. The arrangement, therefore, permits during normal effective operation of the engine deliberate adjustment and/or modification, following the different conditions of use under which the vehicle may be employed, of the characteristic curve representing the variations of the torque capable of being transmitted by the clutch as a function of the engine speed.—*January* 14, 1959.

MACHINE TOOLS

807,921. April 20, 1955.—TOOLS FOR LATHES OR BORING BARS, Birmingham Small Arms Company, Ltd., Armoury Road, Small Heath, Birmingham, 11. (*Inventor: Lionel Fine.*)

This invention relates to single-point, metal-cutting tools having a separate cutting tip secured by mechanical means. Alternative constructions are shown and we describe one by way of example. The tool body or shank has in it a groove one side of which is tapered to form a dovetail cross section. A tip *A*



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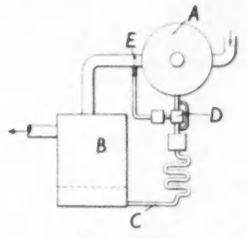
having both sides tapered is fitted within the groove, one side engaging the tapered side of the groove. Along the other side of the groove a recess is formed in the body to receive a wedge *B*, the tapered side of which engages the tapered side of the tip so that when the wedge is in position the tip is locked as shown. A threaded hole in the body extends below the wedge recess and is counterbored to the depth of the recess. The wedge is formed with a countersunk semi-circular hole complementary with that in the body. When the tip and wedge are in position a set screw *C* is inserted through the hole in the wedge and screwed into the body. The head of this set screw acts on the countersunk portion of the wedge, drawing it down into the recess and locking the tip between the tapered side of the groove and the side of the wedge. When wear takes place on the tip, or after re-grinding, the wedge is slackened, the tip is moved out and the wedge retightened.—*January* 28, 1959.

COMPRESSORS

808,172. April 23 1956.—INSTALLATIONS FOR COMPRESSING AIR OR GAS, The Consolidated Pneumatic Tool Company, Ltd., 232, Dawes Road, London, S.W.6. (*Inventor: John Reginald Quertier.*)

This invention relates to compressors of the liquid-flooded type and is intended to provide a residual flow of liquid, adequate for lubrication and sealing when the temperature of the compressed air or gas delivered falls to its minimum value—that is, under conditions of no load on the compressor, or on starting. An embodiment of the invention is described with reference to the accompanying diagram. The delivery port of the compressor *A* is connected to a receiver *B* embodying a separator for separating from the air the cooling liquid discharged by the compressor. The receiver has an outlet through which the separated liquid, collected in the base, is discharged into the circulating pipe *C* by the pressure of air in the receiver. This pipe leads by way of a heat exchanger, a filter, and a valve *D* to an inlet port in the compressor casing. The compressor is preferably controlled in dependence upon the pressure in the receiver by throttling the inflow of air through the intake. A thermally responsive element *E* in the compressor delivery pipe is connected by a fluid-filled tube (and, if desired, by way of a fluid-operated servomotor), so as to actuate the valve *D*. The arrangement is such that the valve is fully open when the compressed air being delivered is at a predetermined maximum temperature, and is closed when the compressed air is at a predetermined minimum temperature. The valve *D* is provided with a by-pass, whereby the circulation of the liquid is not completely stopped when the valve is closed, thereby



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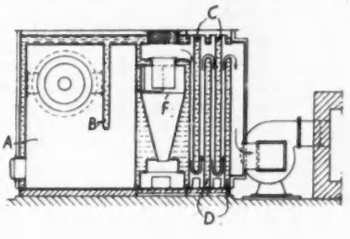
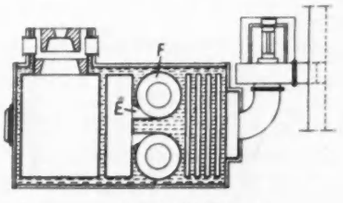
preventing failure of the lubricating system when the temperature of the air on the delivery side of the compressor is at a minimum under conditions of low or no load. Thus a flow of liquid adequate for lubrication is supplied to the compressor under the pressure obtaining in the receiver at all times, and the flow is automatically increased in response to rise of temperature of the air delivered by the compressor consequent upon increase of load so that the rate of abstraction of heat by the liquid is increased.—*January* 28, 1959.

BOILERS

808,207. June 17, 1955.—IMPROVEMENTS IN BOILERS, Aktiebolaget Gustavsbergs Fabriker, Gustavsberg, Sweden.

An object of this invention is to increase the efficiency of a heating boiler, first, by preventing soot and dust deposit on the heating surfaces of the convection part of the boiler; secondly, by improving the combustion. In the boiler shown in the drawing the water space is formed by a jacket surrounding the furnace *A*, a hollow wall *B*, depending from the upper part of the jacket, and by a number of hollow walls *C*,





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depending from the upper wall, and by hollow walls *D* projecting up from the bottom in the intermediate spaces between the walls. The hollow walls form the convection part of the boiler and offer a passage to the flue gases, as indicated by arrows. Flue gas passages *E* extend from the rear wall of the furnace to cyclones *F* mounted behind the furnace. The cyclones are surrounded by a water jacket connected to the water space of the boiler: extending through the upper wall of the water jacket are tubular members opening into a space through which the gases flow. The lower portions of the cyclones open at the bottom into a collecting space for the ashes and soot which are separated from the combustion gases in the upper part of the cyclones. Dampers may be arranged so that one or more of the cyclones may be cut off according to the load. The combustion gases flowing into the passage *E* from the furnace generally contain stray cinders as well as soot, and they flow tangentially into a cyclone at a relatively high velocity. Solid particles moving out toward the circumference of the cyclone fall down into the collecting space, whilst the gases relieved of solid particles escape at the top through the tubular member and pass through the passages between the water walls to the flue gas outlet.—*January* 28, 1959.

Launches and Trial Trips

THESEE, cargo ship ; built by the Ateliers et Chantiers de Bretagne for the Societe Navale Caennaise ; length between perpendiculars 397ft 3½in, breadth moulded 49ft 11in, depth 28ft 6in, deadweight 7000 tons at 21ft 0½in draught, speed 13¼ knots ; four holds, eight 5-ton winches, two Bipod masts ; three 130kW diesel-driven and one 110kW shaft-driven generators ; two S.E.M.T.-Pielstick, four-stroke, single-acting, supercharged diesel engines, 2560 h.p. each at 420 r.p.m., drive one shaft through reduction gearing and hydraulic couplings. Trial November.

OVERSEAS PIONEER, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for London and Overseas Tankers, Ltd. ; length between perpendiculars 560ft, breadth moulded 80ft, depth moulded 42ft 3in, draught 32ft 4½in, deadweight 24,900 tons ; twenty-seven cargo oil tanks, one cargo pump room, three 1000 tons per hour turbine-driven centrifugal pumps, three 150 tons per hour vertical duplex steam stripping pumps ; two 325kW turbine-driven generators and one 100kW diesel-driven generator ; one set of Richardsons Westgarth double reduction geared turbines, 7300 s.h.p. at 100 propeller r.p.m., two Foster-Wheeler " D " pattern water-tube boilers supply steam at 450 lb per square inch and 750 deg. Fah. Trial December 1.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME AND PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., March 2.—BOLTON BRANCH : Railway Hotel, Trinity Street, Bolton, " Miniature Circuit Breakers," J. A. Robbins, 7.45 p.m. ★ LEEDS BRANCH : Great Northern Hotel, Leeds, " Railway Electrification," 7.30 p.m. ★ N.E. LONDON BRANCH : Angel Hotel, Ilford, " Theatre Lighting," F. E. Brown, 8 p.m.

Tues., March 3.—READING AND DISTRICT BRANCH : Electricity Board Demonstration Room, Market Square, Reading " Mercury-Arc Rectification," 7.30 p.m. ★ W. LONDON BRANCH : Windsor Castle Hotel, 134, King Street, Hammersmith, W.6, " Wired Television Systems—Installation and Maintenance Problems," L. A. Isaacson, 7.30 p.m.

Wed., March 4.—HALIFAX BRANCH : Crown Hotel, Horton Street, Halifax, " Ventilation," 7.45 p.m. ★ N. LONDON BRANCH : Wood Green Town Hall, Wood Green, N.22, " High Frequency Heating," 7.45 p.m. ★ PRESTON BRANCH : R.A.F.A. Club, East View, Preston, " Supply and Consumption of Electricity," J. Prowse, 7.30 p.m.

Thurs., March 5.—S.W. LONDON BRANCH : " Prince of Wales " Hotel, S.W.19, Open Debate, 7.45 p.m.

Fri., March 6.—BRISTOL AND WEST OF ENGLAND BRANCH : Grand Hotel, Bristol, Tape-Recording of A.S.E.E. Diploma Scheme Oral Examination, 8 p.m. ★ LIVERPOOL AND DISTRICT BRANCH : Industrial Development Centre, M.A.N.W.E.B., Paradise Street, Liverpool, 1, " Aspects of Electrical Installations and Modern Building Construction," 7.30 p.m. ★ STOKE AND CREWE BRANCH : Royal Hotel, Crewe, " A.C. Control Gear," S. H. Harding, 7.30 p.m.

BRITISH INSTITUTE OF MANAGEMENT

To-day, Feb. 27.—Town Hall, Leamington Spa, 1959 Midland Management Conference on " Management in a Competitive World."

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, Feb. 27.—SOUTH MIDLANDS SECTION : North Gloucestershire Technical College, Cheltenham, " Micro-Miniaturization," G. W. A. Dummer, 7 p.m.

Thurs., March 5.—N.W. SECTION : Reynolds Hall, College of Technology, Sackville Street, Manchester, 1, " Closed Circuit Television Equipment," R. E. Blythe, 6.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

To-day, Feb. 27.—BIRMINGHAM CENTRE : Regent House, St. Philip's Place, Colmore Row, Birmingham, Annual General Meeting ; Address by the President, 6 p.m.

Wed., March 4.—EDINBURGH CENTRE : Y.M.C.A., 14, South St. Andrew Street, Edinburgh, " Lighting and Safety in Building Operations and Works of Engineering Construction," J. Gordon Scott, 6.30 p.m.

Thurs., March 5.—GLASGOW CENTRE : British Lighting Council, 29, St. Vincent Place, Glasgow, C.1, " Lighting and Safety in Building Operations and Works of Engineering Construction," J. Gordon Scott, 6.30 p.m.

INSTITUTE OF FUEL

Wed., March 4.—YORKSHIRE SECTION : Royal Station Hotel, Hull, " Treatment of Water for the Prevention of Scale and Corrosion," G. T. Peat, 2.30 p.m.

Thurs., March 5.—MERSEYSIDE SUB-SECTION : Liverpool Engineering Society, 9, The Temple, Dale Street, Liverpool, Annual General Meeting and Films, 7 p.m. ★ BRISTOL AREA : Chemical Department, The University, Woodland Road, Bristol, 8, " Some Aspects of Modern Refinery Operations," D. T. Leahy, 6.30 p.m.

Fri., March 6.—S. WALES SECTION : S. Wales Electricity Board Showrooms, Kingsway, Swansea, " Gas Producers with special reference to S. Wales Coals," G. W. C. Allan, 6 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., March 2.—STUDENT LECTURE : Memorial Building, 76, Mark Lane, London, E.C.3, " Marine Lubrication," G. H. Clark, 6.30 p.m.

Tues., March 3.—JOINT NUCLEAR MARINE PROPULSION PANEL : Memorial Building, 76, Mark Lane, London, E.C.3, " Some Metallurgical Features of Nuclear Reactors," H. M. Finniston, 5.30 p.m.

INSTITUTE OF PETROLEUM

Wed., March 4.—61, New Cavendish Street, London, W.1, " Looking Ahead : On the Threshold of Our Second Century," H. E. Snow, 5.30 p.m.

INSTITUTE OF REFRIGERATION

Thurs., March 5.—Institute of Marine Engineers, Memorial Building, 76, Mark Lane, London, E.C.3, " Applications of Refrigeration to Horticultural Produce in the Netherlands," T. Van Heile, 5.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., March 4.—MIDLANDS BRANCH : College of Technology, Gosta Green, Birmingham, " Reynolds' Analogy and Mass Transfer," F. H. Garner, V. G. Jenson and R. B. Keey, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., March 3.—Great George Street, Westminster, London, S.W.1, " Development in Overhead Electrification of Railways as it Effects the Civil Engineer," R. E. Sadler, 5.30 p.m.

Thurs., March 5.—N.W. ASSOCIATION : Engineers' Club, Albert Square, Manchester, " Investigations of Navigation and Bridging Problems of the River Dee," J. A. L. Matheson, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Feb. 27.—SOUTHERN CENTRE : South Dorset Technical College, Weymouth, " Survey of Recent Developments in Marine Radar," A. L. P. Milwright, 6.30 p.m.

Sat., Feb. 28.—LONDON GRADUATE AND STUDENT SECTION : Visit to Tower Bridge, London, E.1, 3 p.m.

Mon., March 2.—E. ANGLIAN SUB-CENTRE : Cavendish Laboratory, Cambridge, " The Recognition of Moving Vehicles by Electronic Means," T. S. Pick and A. Readman, 8 p.m. ★ MERSEY AND N. WALES CENTRE : Royal Institution, Colquitt Street, Liverpool, " P. V. Hunter—Electrical Engineering in our Time," C. O. Boyse, 6.30 p.m. ★ N.E. RADIO AND MEASUREMENT GROUP : King's College, Newcastle upon Tyne, " High-Quality Microphones," M. L. Gayford, 6.15 p.m. ★ S. MIDLAND CENTRE : College of Technology, Gosta Green, Birmingham, Brains Trust, 6 p.m. ★ MAIDSTONE CENTRE : Medway College of Technology, Chatham, " Domestic High-Fidelity Reproduction," 6.30 p.m.

Tues., March 3.—MEASUREMENT AND CONTROL SECTION : Savoy Place, London, W.C.2, " The Influence of Consumers' Load Consumption Characteristics on Metering Practice," L. B. S. Golds, 5.30 p.m. ★ E. MIDLAND CENTRE : College of Further Education, Loughborough, " Small Squirrel Cage Motors," A. J. Holland, " Sub-Stations for the Super Grid," R. W. Hughes, 6 p.m. ★ N.E. CENTRE : College of Further Education, Workington, " Silicone Electrical Insulation," J. H. Davis, 7 p.m. ★ SHEFFIELD SUB-CENTRE AND N. MIDLAND CENTRE : Town Hall, Barnsley, " The Delti: Locomotive," C. M. Cock, 6.45 p.m. ★ N.W. CENTRE : Engineers' Club Albert Square, Manchester, " Subscriber Trunk Dialling," D. A. Barron, 6.15 p.m. ★ N. IRELAND CENTRE : Sir William Whitla Hall, Queen's University, Stranmilles Road, Belfast, " Automation," H. A. Thomas, 7.30 p.m.

Wed., March 4.—TEES-SIDE SUB-CENTRE : Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, " P. V. Hunter—Electrical Engineering in our Time," C. O. Boyse, 6.30 p.m. ★ SOUTHERN CENTRE : The University, Southampton, " Transistor Voltage Regulators for Alternators," E. E. Ward, 6.30 p.m.

Thurs., March 5.—ORDINARY MEETING : " The Reliability and Life of Impregnated Paper Capacitors," J. P. Pitts, 5.30 p.m. ★ S. MIDLAND CENTRE : College of Technology, Gosta Green, Birmingham, Discussion on " Nuclear Technology and the Electrical Engineer," J. Walker, 6.15 p.m.

Fri., March 6.—MEDICAL ELECTRONICS DISCUSSION GROUP : Savoy Place, London, W.C.2, Discussion on " Potted Histories of Instruments Designed for Medical Purposes," opened by H. S. Wolff, and " Co-ordination of Research in Medical Electronics," opened by R. G. Willison, 6 p.m. ★ N.E. CENTRE : Technical College, Carlisle, " The Deltic Locomotive," C. M. Cock, 7 p.m. ★ SHEFFIELD SUB-CENTRE : City Hall, Sheffield, " Automation," H. A. Thomas, 7.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

Fri., March 6.—Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, " Oxford Eastern By-Pass," K. Summerfield, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 27.—INFORMAL DISCUSSION : 1, Birdcage Walk, Westminster, London, S.W.1, " Choice of Gas Temperature and Steam and Pressure Conditions in Nuclear Power Stations," 6 p.m. ★ LONDON GRADUATES' SECTION : Visit to the Ford Motor Company's new foundry at Dagenham, 2 p.m.

Mon., March 2.—N.E. BRANCH : Neville Hall, Newcastle upon Tyne, " Marine Refrigeration," H. R. Howells, 6 p.m.

Wed., March 4.—LONDON GRADUATES' SECTION : Southall Technical College, Beaconsfield Road, Southall, Middlesex, " The Skidding Resistance of Roads and its Measurement," K. H. F. Cardew, 6.30 p.m. ★ N.E. GRADUATES' SECTION : Visit to the Elswick Works of Vickers-Armstrong, Ltd., 2 p.m.

Thurs., March 5.—INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on " Engineering Standards : Development and Use," 6 p.m. ★ SCOTTISH BRANCH : Royal College of Science and Technology, Glasgow, " Natural Circulation Investigations on an Experimental 2-Tube Boiler," A. M. Laird, A. W. Scott and A. S. T. Thomson, 7.30 p.m. ★ E. MIDLANDS GRADUATES' SECTION : Room 104, College of Technology and Commerce, Leicester, " Electronics for the Mechanical Engineer," M. J. Hamblin, 7.15 p.m. ★ YORKSHIRE GRADUATES' SECTION : Grand Hotel, Sheffield, " Precision Finishing Machines and Operations," E. D. Haigh, 6.30 p.m.

Fri., March 6.—ORDINARY MEETING IN CONJUNCTION WITH THE STEAM GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, " Approximate Equations for the Properties of Superheated Steam," J. H. Horlock, 6 p.m. ★ WESTERN BRANCH : Cornwall Technical College, Camborne, Chairman's Address, 7.15 p.m.

INSTITUTION OF PLANT ENGINEERS

Wed., March 4.—KENT BRANCH : Kings Head Hotel, High Street, Rochester, Branch Annual General Meeting, 7 p.m. ★ LEICESTER BRANCH : Bell Hotel, Leicester, " Lubrication in Industry—A Critical Survey," T. Collins, 7 p.m.

Thurs., March 5.—SOUTHERN BRANCH : Polygon Hotel, Southampton, Branch Annual General Meeting, to be followed by a discussion, 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Feb. 27.—NORTH MIDLANDS REGION : Louis Room, St. James's Restaurant, St. James's Street, Derby, " Automobile Testing and Development," H. A. Dean, 7 p.m. ★ WALES REGION : South Wales Institute of Engineers, Park Place, Cardiff, " Compressed Air and Some of its Practical Applications," W. J. Ford, 7 p.m.

Tues., March 3.—NOTTINGHAM SECTION : Works visit to Shell Oil Refinery, Stanlow, 8 a.m.

Wed., March 4.—NOTTINGHAM SECTION : Reform Club, Victoria Street, Nottingham, Annual General Meeting, 7 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Feb. 27.—MIDLAND COUNTIES BRANCH : James Watt Memorial Institute, Birmingham, " Some Structural Problems Particular to Aircraft Design," A. J. Troughton, 6.30 p.m.

Tues., March 3.—N. COUNTIES BRANCH : Cleveland Scientific and Technical Institution, Middlesbrough, " Design of the New Industrial Training Centre at I.C.I., Ltd., Wilton Works," M. E. Thornely, and " Some Aspects of Industrial Training," N. E. Langdale, 6.30 p.m. ★ N. IRELAND BRANCH : College of Technology, Belfast, " Modern Methods of Timber Engineering," H. Tottenham, 6.45 p.m.

Wed., March 4.—N. COUNTIES BRANCH : Neville Hall, Newcastle upon Tyne, " Design of the New Industrial Training Centre at I.C.I., Ltd., Wilton Works," M. E. Thornely, and " Some Aspects of Industrial Training," N. E. Langdale, 6.30 p.m. ★ YORKSHIRE BRANCH : Royal Station Hotel, York, " The Clifton Bridge Project," C. J. Minter and A. Goldstein, 6.30 p.m.

Fri., March 6.—LANCASHIRE AND CHESHIRE BRANCH : College of Building, Clarence Street, Liverpool, " Design of Reinforced Concrete Sections with special regard to C.P.114, 1957," C. E. Reynolds, 6.30 p.m. ★ W. COUNTIES BRANCH : University Engineering Laboratories, Bristol, " Suspension Bridges To-day," Sir Alfred Pugsley, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 27.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, " Computers and Materials Handling," W. J. Kease and A. C. Quarterman, 7 p.m.

Wed., March 4.—MIDLAND SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, " Power Cables Abroad," Mr. Michaels, 7 p.m.

Fri., March 6.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Film Evening, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Feb. 27.—Engineers' Club, Albert Square, Manchester, 2, " Electrical Models and Analogues," E. Bradshaw, 6.45 p.m.

MANCHESTER STATISTICAL SOCIETY

To-day, Feb. 27.—Portico Library, 57, Mosley Street, Manchester, " Applications of Linear Programming Techniques to Problems of Production and Distribution," A. Baines, 6 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Feb. 27.—Lecture Theatre, Mining Institute, Newcastle upon Tyne, " Some Engineering Developments in the Nuclear Power Field," A. T. Bowden, 6.15 p.m.

Wed., March 4.—STUDENT SECTION : Bolbec Hall, Newcastle upon Tyne, Senior Address, P. Denham Christie, 7 p.m.

PRESTRESSED CONCRETE DEVELOPMENT GROUP

Wed., March 4.—Royal Commonwealth Society, Craven Street, London, W.C.2, " How Can the Advantages of Prestressed Concrete Best be Utilised ? " H. Rüsch, 6 p.m.

REINFORCED CONCRETE ASSOCIATION

Mon., March 2.—N.W. BRANCH : College of Technology, Sackville Street, Manchester, " The Architectural Expression of Structural Concrete," W. A. Gibbon, 6.45 p.m.

Tues., March 3.—N.W. BRANCH : Liverpool Engineering Society, The Temple, 24, Dale Street, Liverpool, " Prestressed Concrete Tanks," L. R. Creasy, 6.30 p.m. ★ MIDLAND COUNTIES BRANCH : Birmingham and Midland Institute, Paradise Street, Birmingham, " The Rolling of Steel Bars," 6 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., March 2.—12, Great George Street, Westminster, London, S.W.1, " Implementing the Franks Report," Sir Sydney Littlewood, 5.45 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., March 4.—CORROSION GROUP : 14, Belgrave Square, London, S.W.1, " The Diagnosis of the Causes of Corrosion Failures," 6.30 p.m.

SOCIETY OF ENGINEERS

Mon., March 2.—Geological Society, Burlington House, Piccadilly, London, W.1, " Some Experiences of River Control in Africa," R. G. T. Lane, 5.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

To-day, Feb. 27.—SCOTTISH SECTION : Scottish Building Centre 425, Sauchiehall Street, Glasgow, " Data Handling in the Process Industries," A. Parsons, 7.15 p.m.

Thurs., March 5.—DATA PROCESSING SECTION : Manson House, Portland Place, London, W.1, Symposium on " The Use of Data Recorded on Industrial Plant," 6 p.m.

TELEVISION SOCIETY

To-day, Feb. 27.—Cinematograph Exhibitors Association, 164, Shaftesbury Avenue, London, W.C.2, Film, " The Wide Wide World," 7 p.m.

Advanced Engineering Courses

Management Appreciation Course in Work Study. LOUGHBOROUGH COLLEGE OF TECHNOLOGY, LOUGHBOROUGH, LEICESTERSHIRE. Two-day course in work study, Wednesday and Thursday, April 22 and 23. Applications for reservations should be sent to James France, M.I.Mech.E., Head of Department of Industrial Engineering. Fees, tuition £5, residence £3.

International Course in Hydraulic Engineering. THE NETHERLANDS UNIVERSITIES FOUNDATION FOR INTERNATIONAL CO-OPERATION, Molenstraat 27, The Hague, The Netherlands. Three programmes have been compiled from the subjects given in the course. They are : (*a*) Tidal and Coastal Engineering (including harbours) ; (*b*) Reclamation ; (*c*) Rivers and Navigation Works (including ground water recovery). The course is open to those who have received a thorough preliminary training in engineering. It will begin on October 21, 1959, with registration and the introductory period, the actual instruction commencing on October 27. The course will terminate on September 8, 1960. The tuition fee is 1200 Dutch guilders.

Basic Principles of Nuclear Engineering. DEPARTMENT OF EXTRA-MURAL STUDIES, University of Liverpool, 9, Abercromby Square, Liverpool, 7. A short introductory course, April 12 to 18, intended primarily for qualified engineers and others who wish to acquire some understanding of the problems of large-scale nuclear power programmes. Fee £21 (non-residential students £15).

Arc and Glow Discharges. DEPARTMENT OF EXTRA-MURAL STUDIES, University of Liverpool, 9, Abercromby Square, Liverpool, 7. Course of twelve lectures, April 12 to 17, covering elementary gas kinetic theory, collision processes and gas swarm phenomena, energy distribution and discharge temperatures, gas conduction theory, plasma equations and properties, plasma energy balance, anode and cathode properties, and low and high pressure glow and arc discharges, special arc types and arc stabilisation, the recovery of arcs and circuit interruption. Fee £15 15s. (non-resident students £10 10s.).

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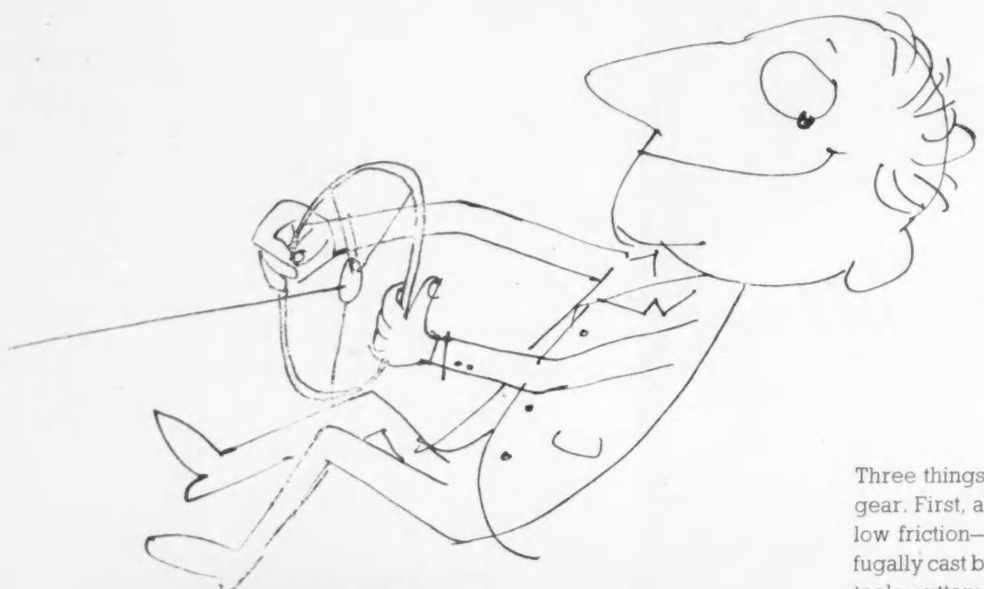

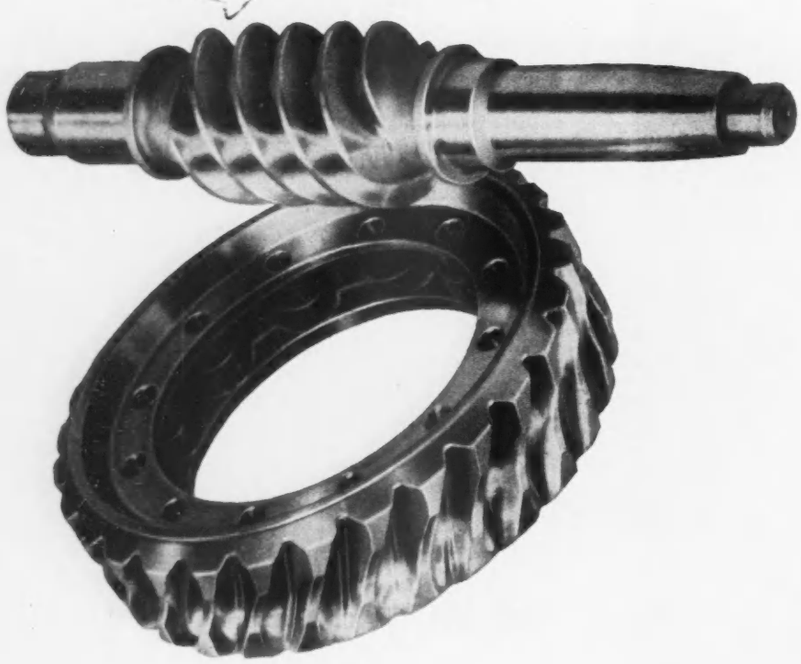

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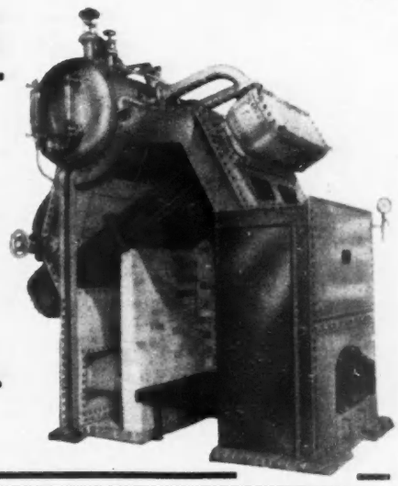

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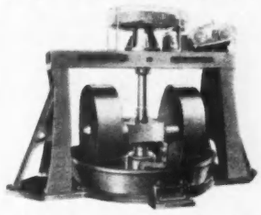

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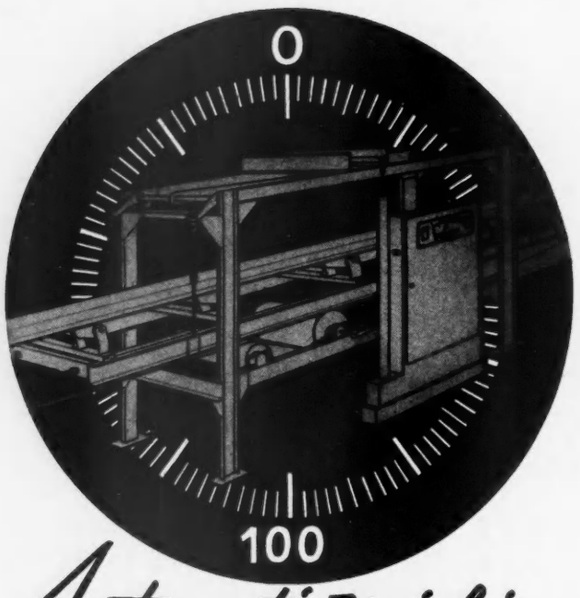

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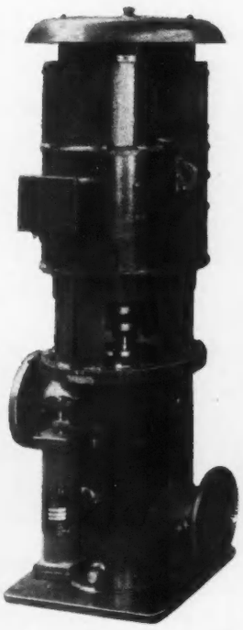

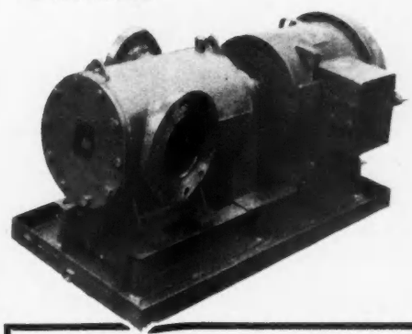

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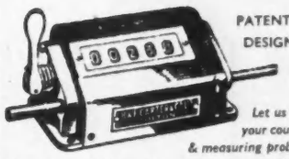

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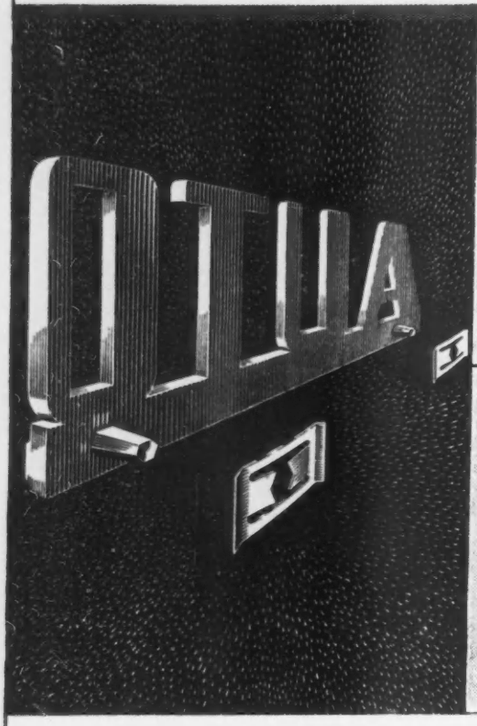

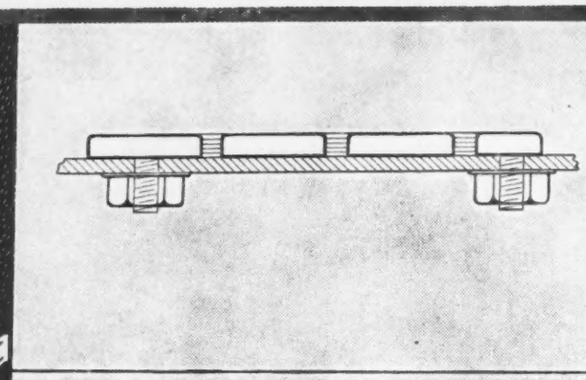

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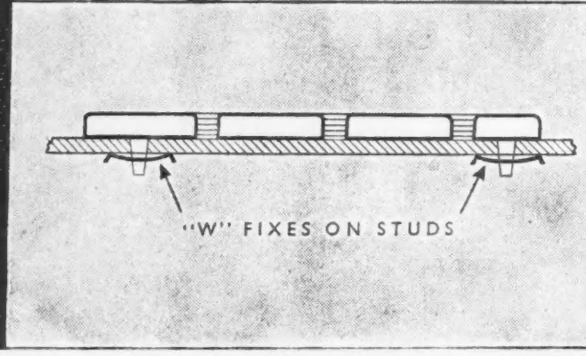
Threaded studs were spot welded (or inserted if die-cast) to the nameplate. To hold this in position, washers and nuts were laboriously assembled with great difficulty especially on blind applications.



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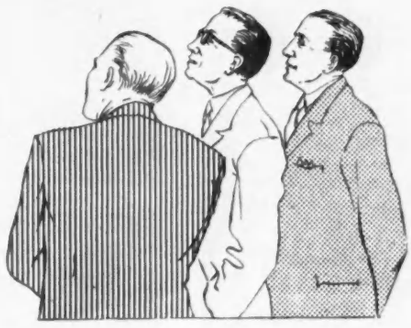

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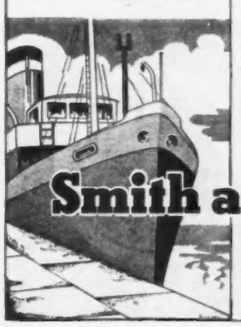

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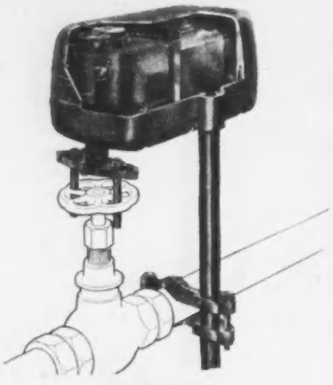

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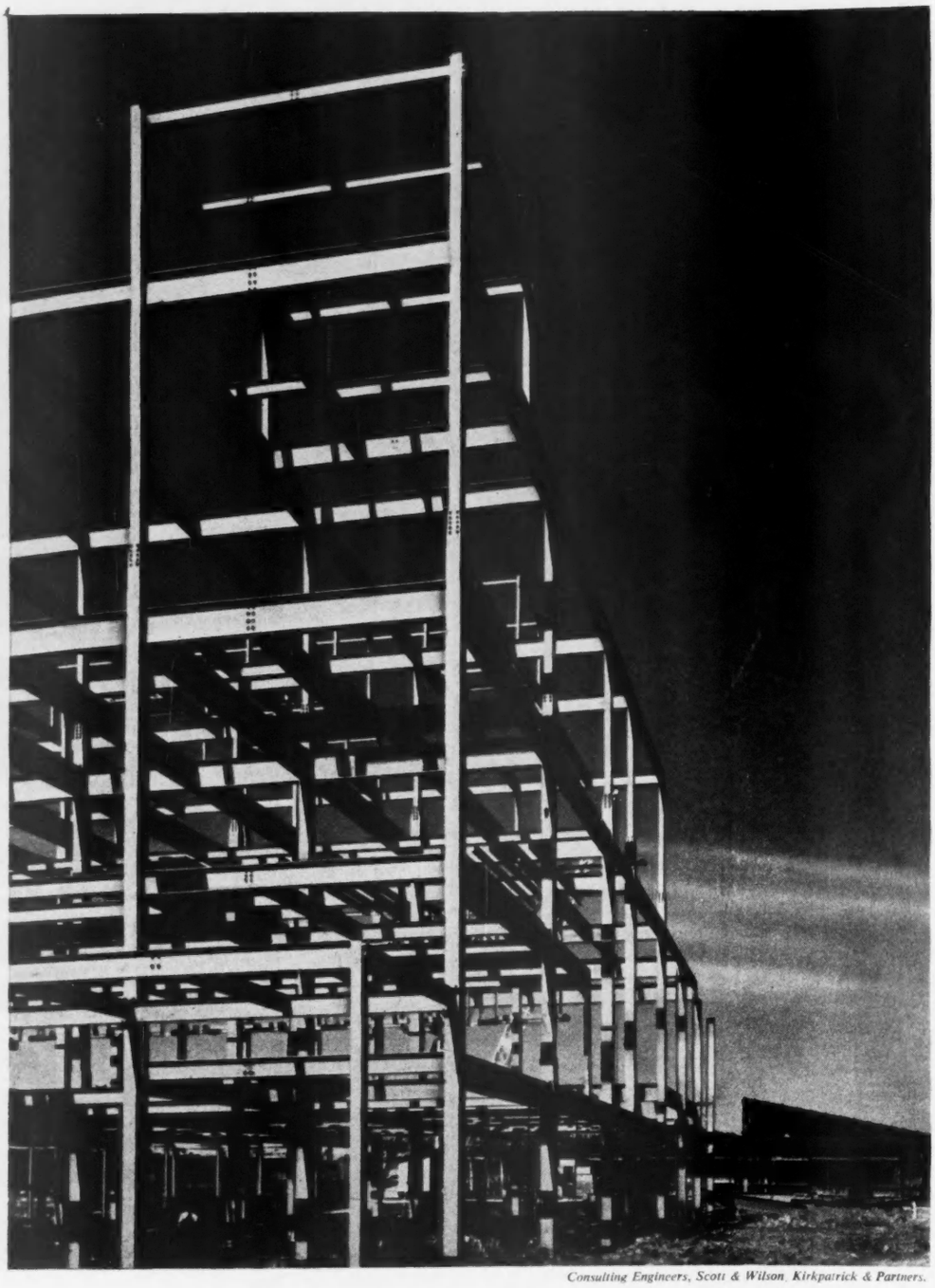

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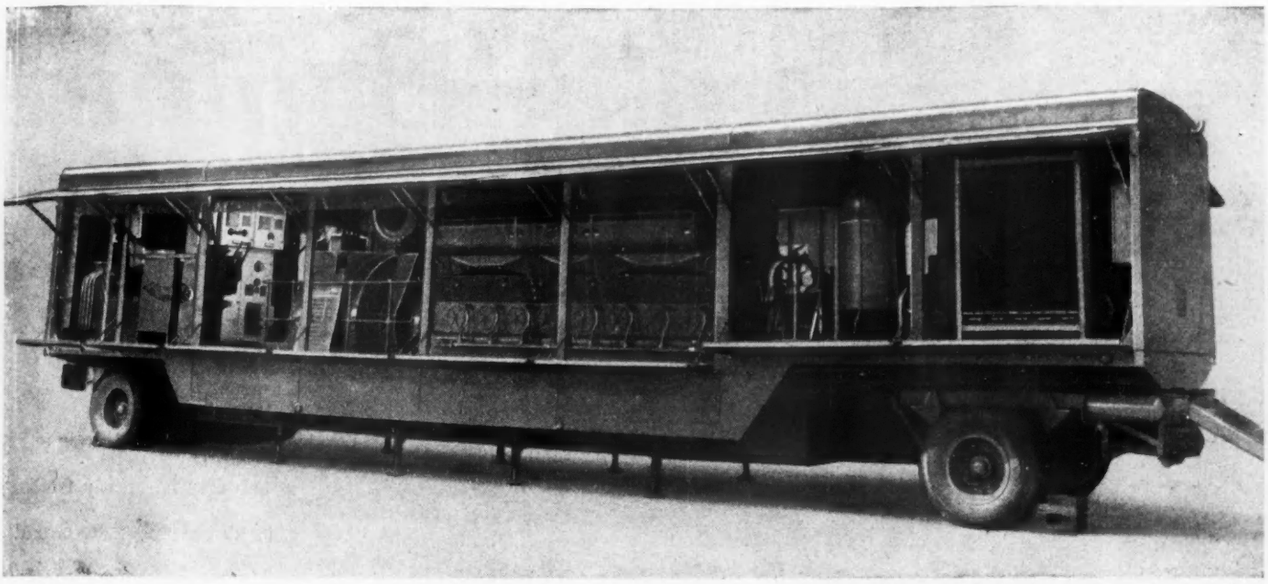
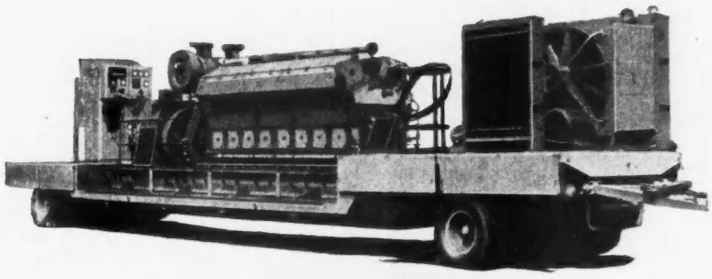
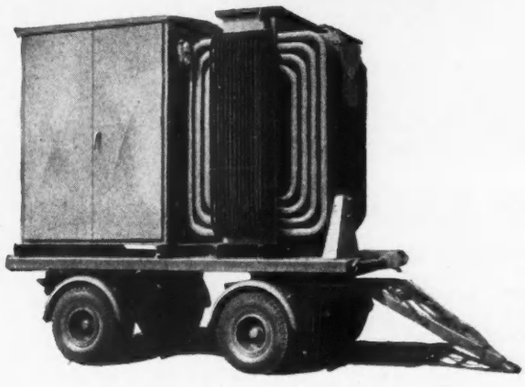


Mobile Power for Venezuela





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Four of the largest mobile generating sets ever constructed have recently been completed by Mirrlees, Bickerton & Day Ltd. for La Corporacion Venezolana de Fomento. Designed for use in townships and works where the local permanent power station is not sufficient to meet the demand, these diesel generators are capable of providing power for an average town.

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CENTRE: *Mirrlees JVS.16 diesel engine and Brush generator in process of being fitted on Generation Trailer.*

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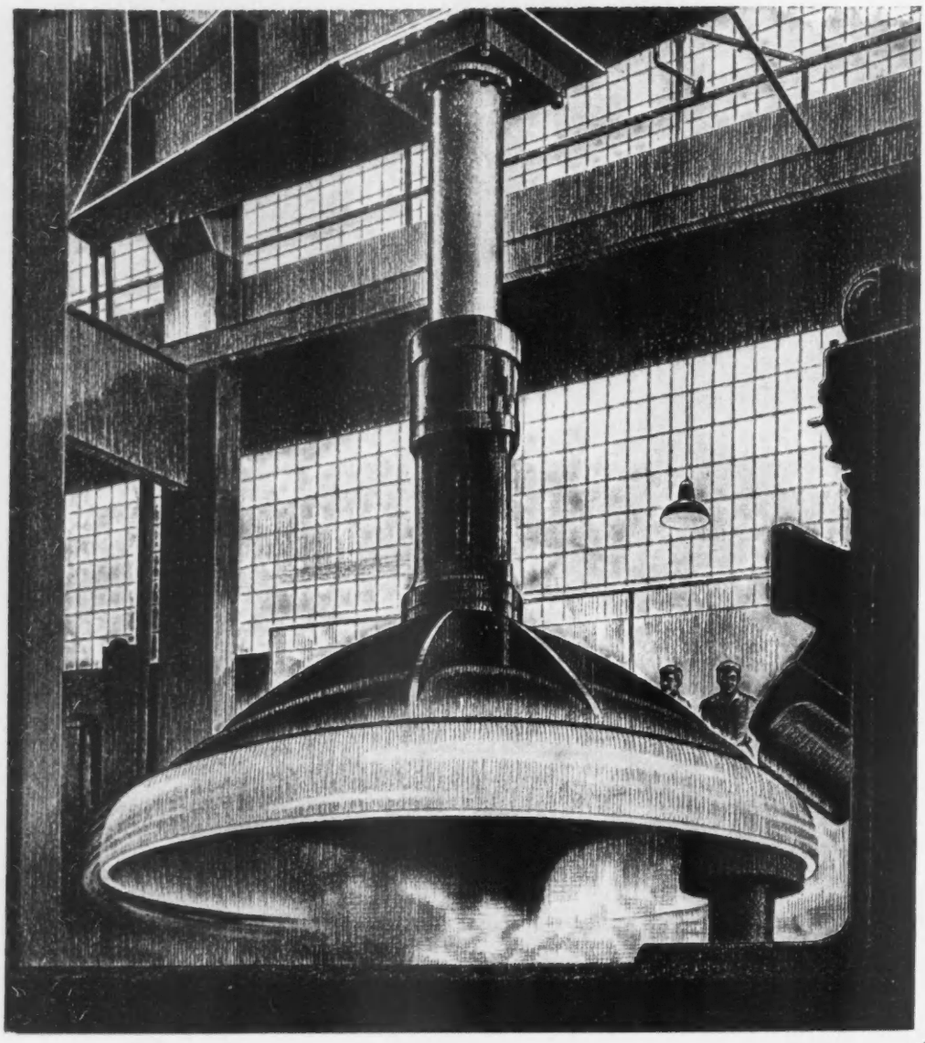

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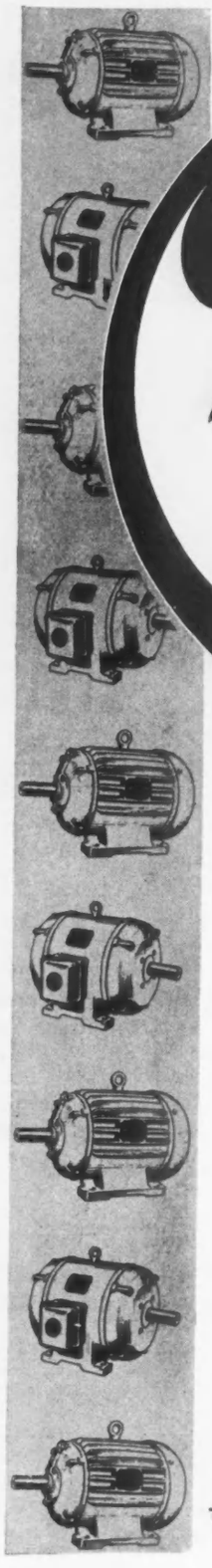

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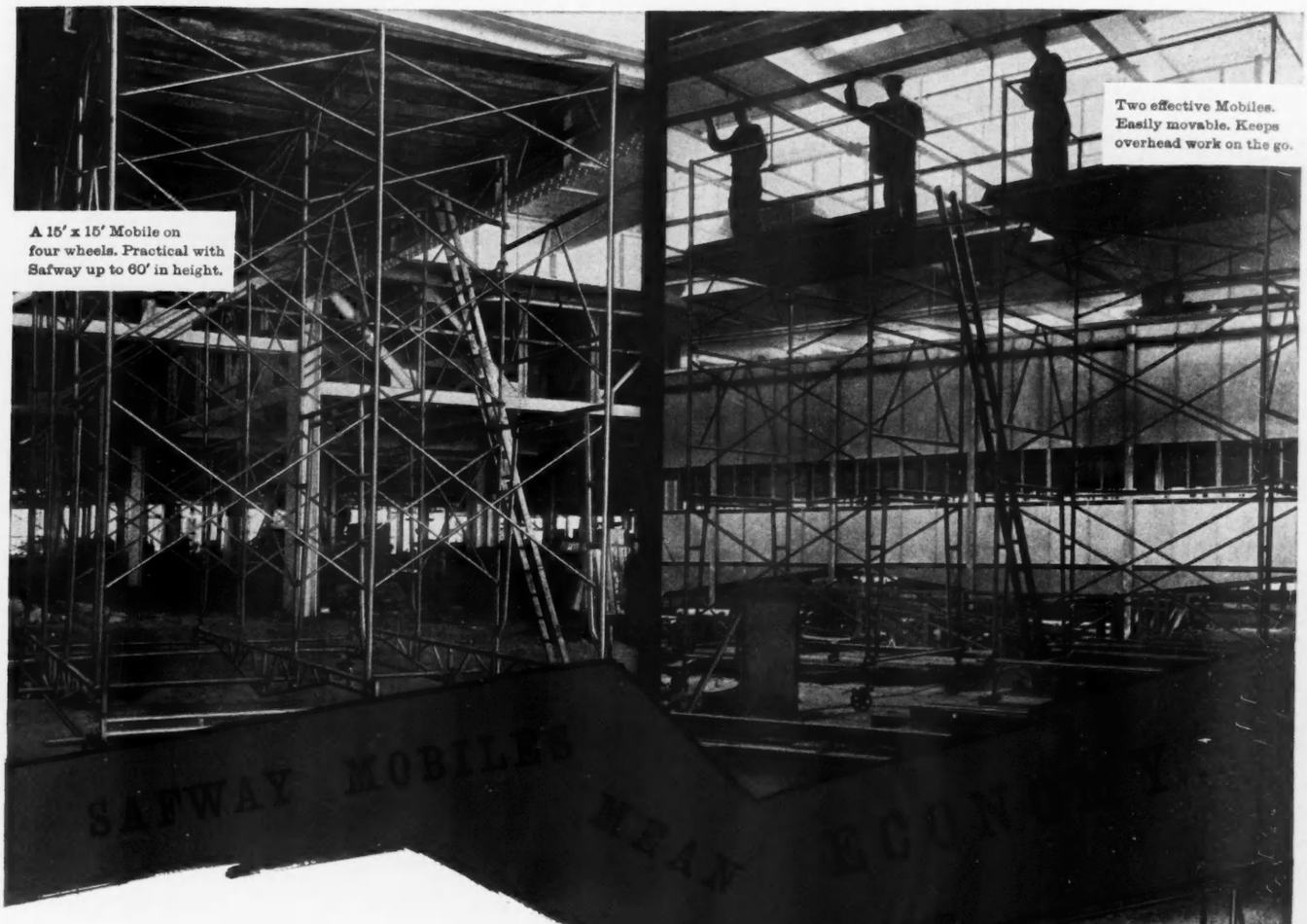

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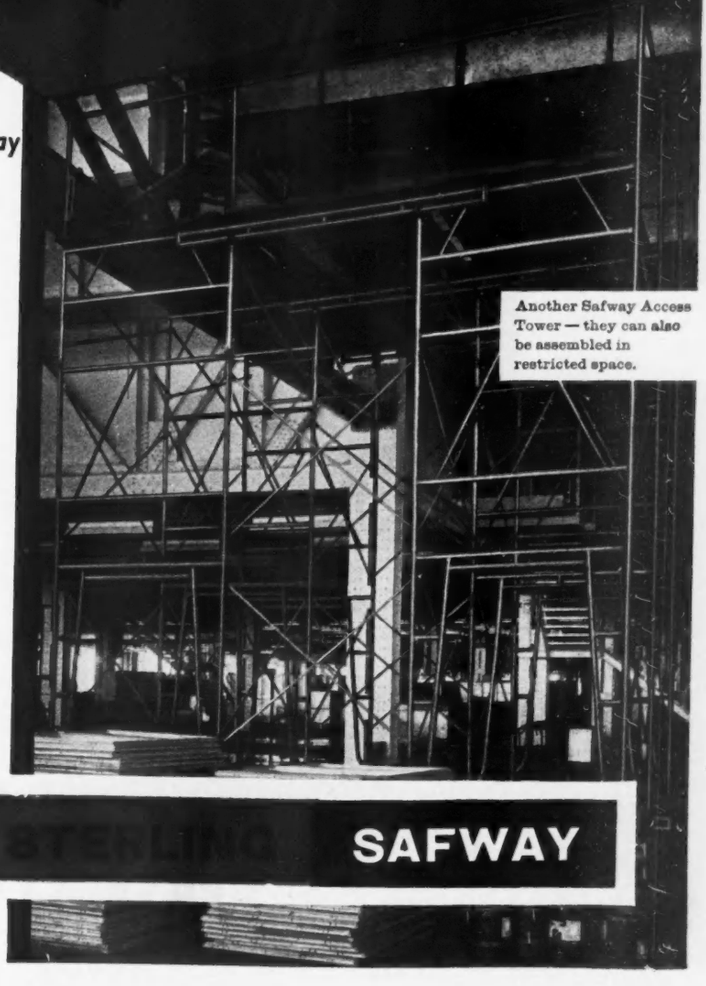

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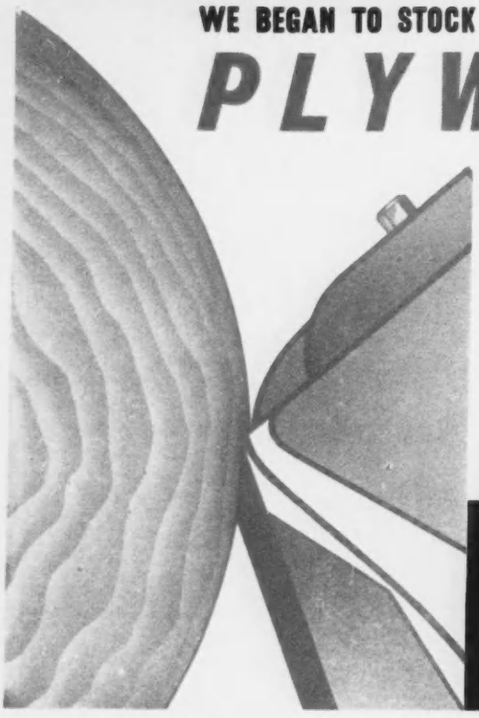

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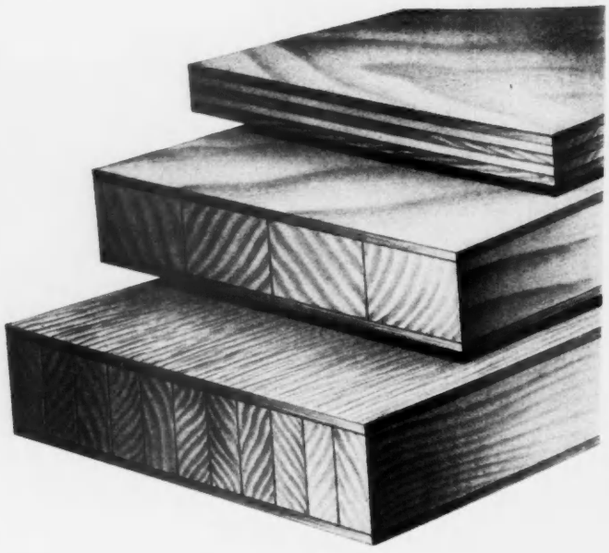

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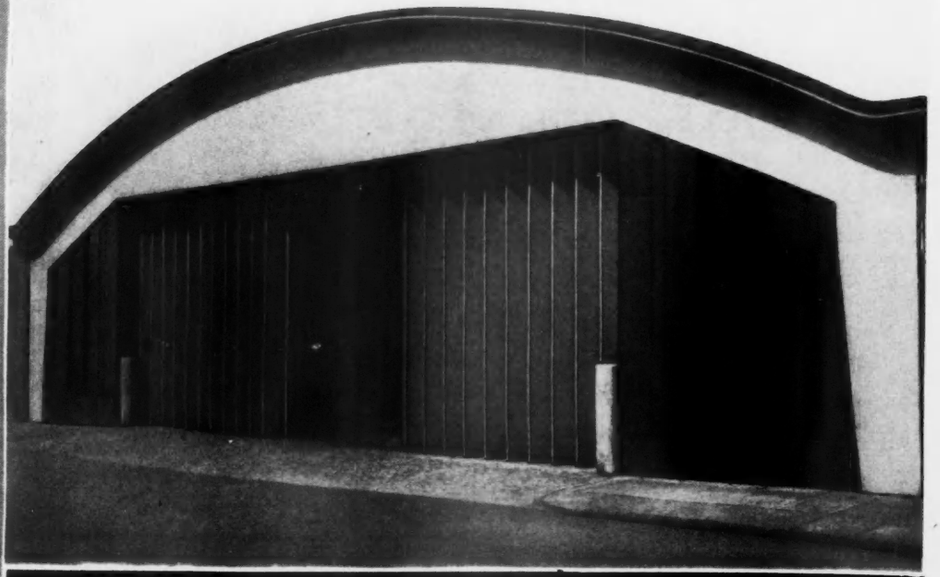

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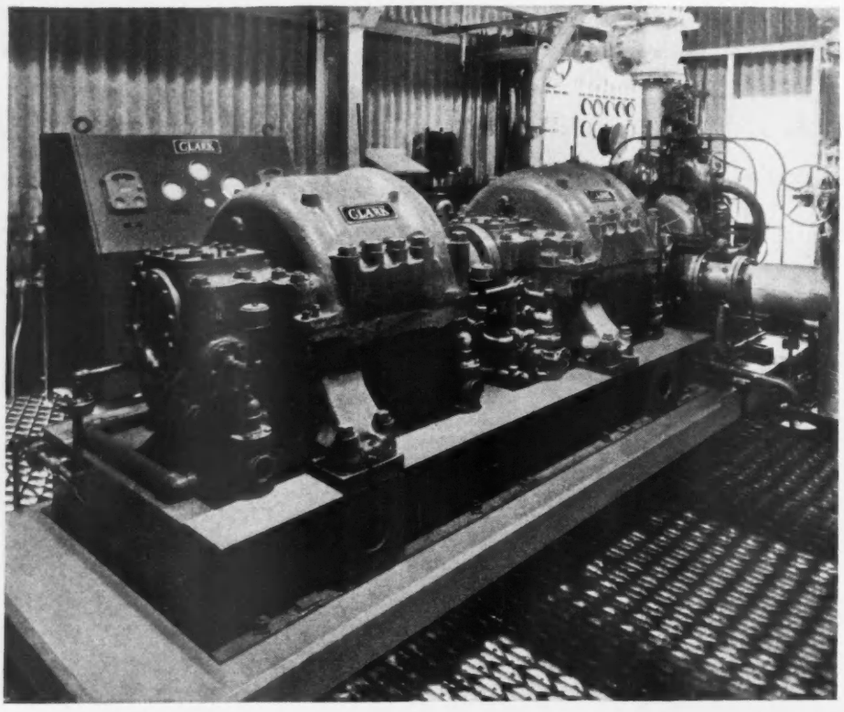

Two Clark No. 2 case 4-impeller centrifugal compressors for process gas on butene dehydrogenation duty at modern refinery of Esso Petroleum Company Limited, Fawley. Low stage 7650 S.C.F.M. High stage 7300 S.C.F.M. 9000 rpm., 1820 bhp. Driven by direct coupled steam turbine.

How Clark Centrifugals serve Esso at Fawley

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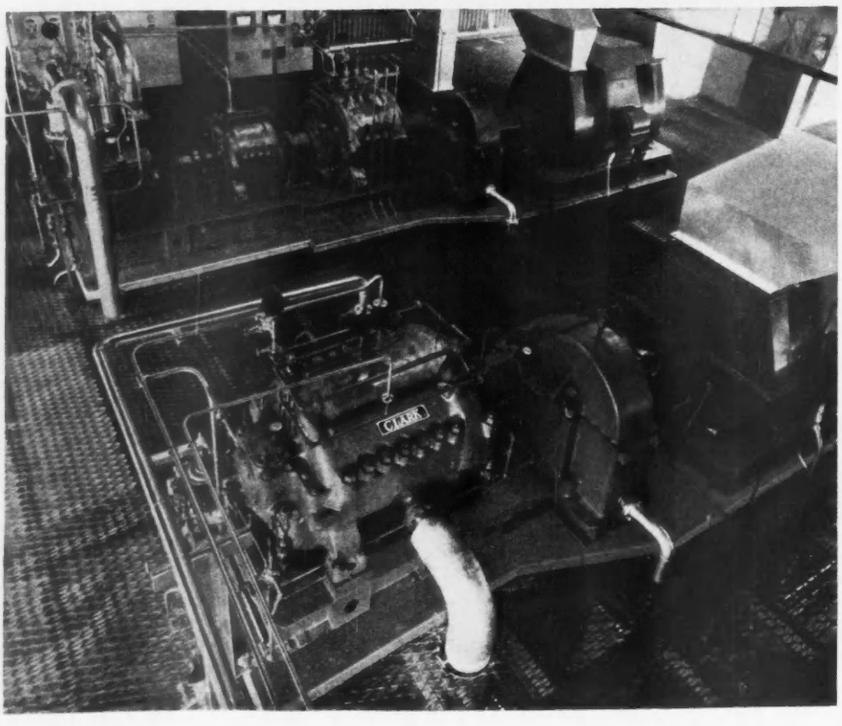

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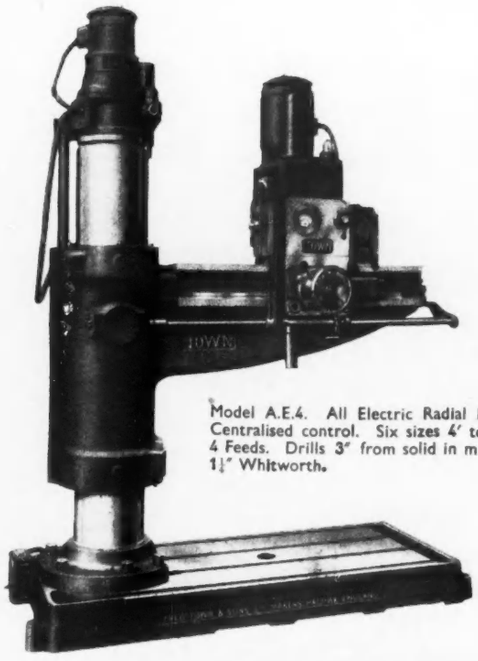
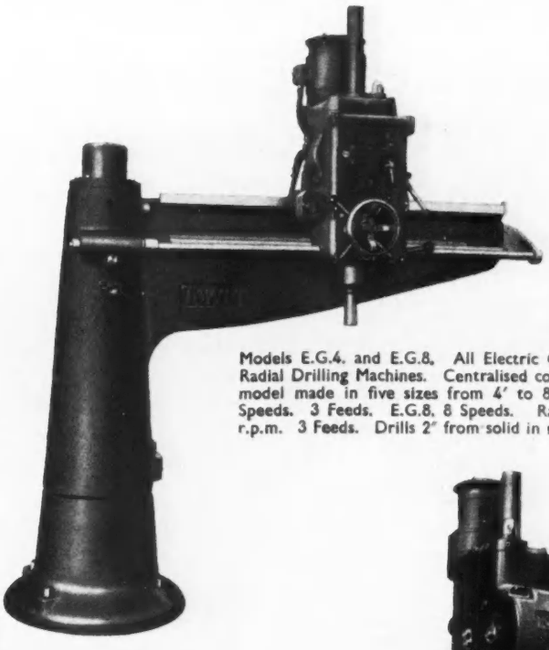


Model A.E.4. All Electric Radial Drilling Machine. Centralised control. Six sizes 4′ to 8′. 12 Speeds. 4 Feeds. Drills 3″ from solid in mild steel and taps 1½″ Whitworth.



Models E.G.4. and E.G.8. All Electric Girder Type Radial Drilling Machines. Centralised control. Each model made in five sizes from 4′ to 8′. E.G.4. 4 Speeds. 3 Feeds. E.G.8. 8 Speeds. Range 20-500 r.p.m. 3 Feeds. Drills 2″ from solid in mild steel.

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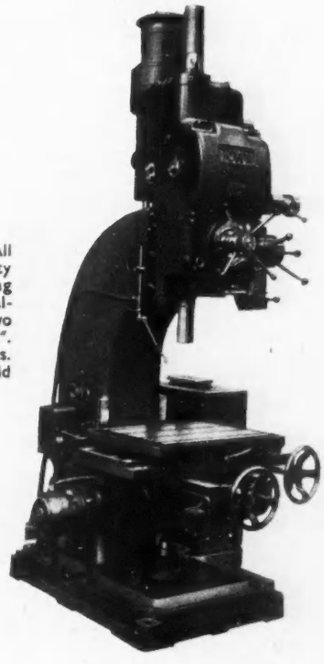
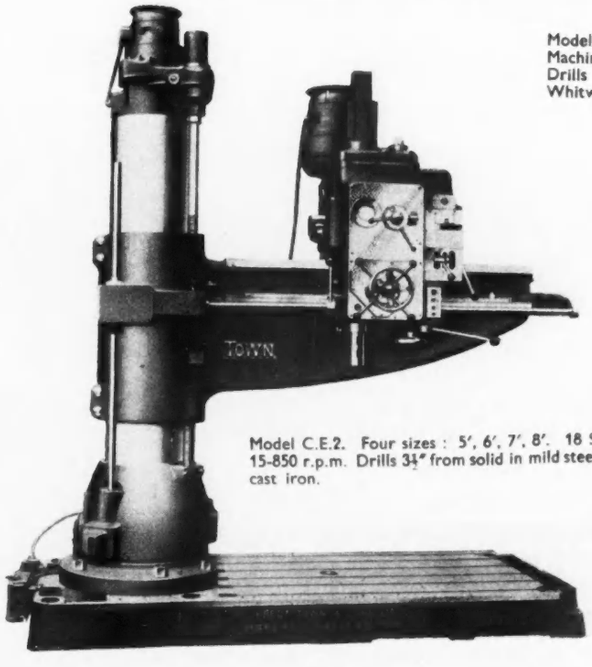
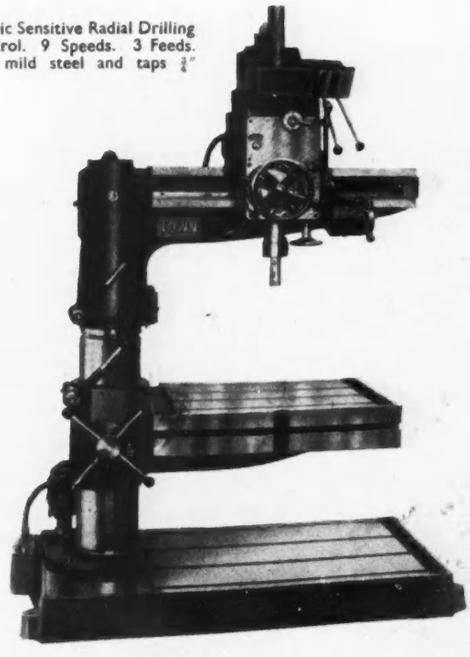


Model A.E.2. All Electric Heavy Duty Vertical Drilling Machine. Centralised control. Two sizes 36″ and 42″. 18 Speeds. 8 Feeds. Drills 3⅛″ from solid in mild steel.



Model C.E.2. Four sizes : 5′, 6′, 7′, 8′. 18 Speeds : 15-850 r.p.m. Drills 3¼″ from solid in mild steel, 3½″ in cast iron.

Model A.E.5. 42″ All Electric Sensitive Radial Drilling Machine. Centralised control. 9 Speeds. 3 Feeds. Drills 1¼″ from solid in mild steel and taps ¾″ Whitworth.



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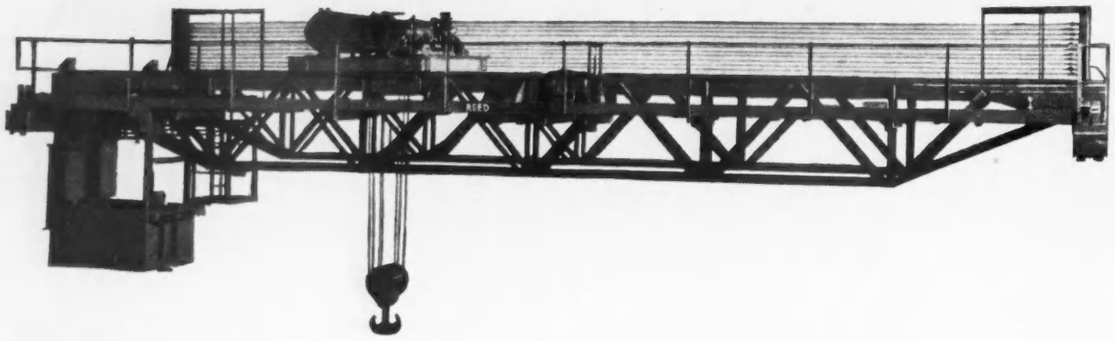

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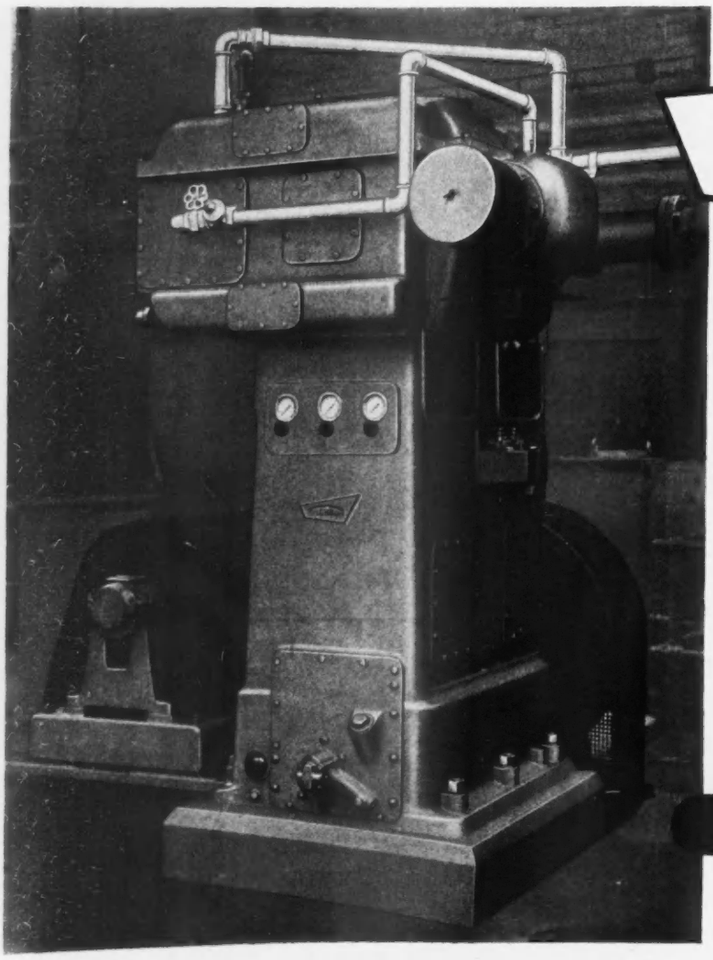

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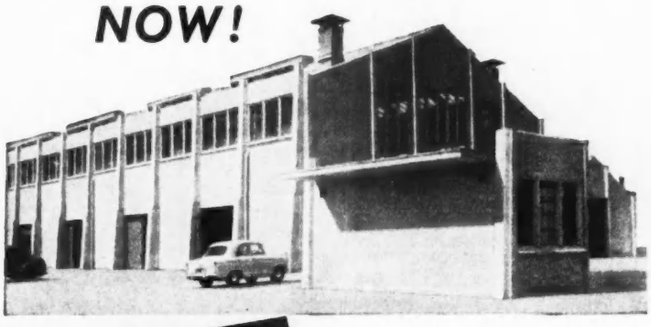

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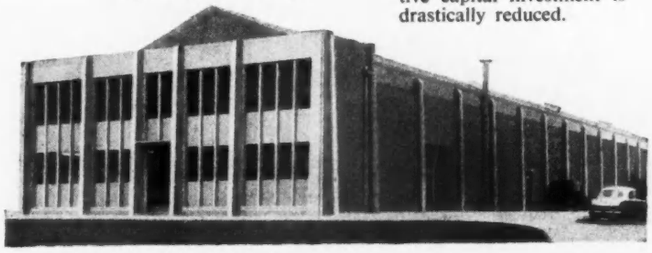

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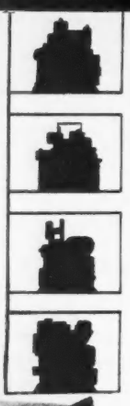

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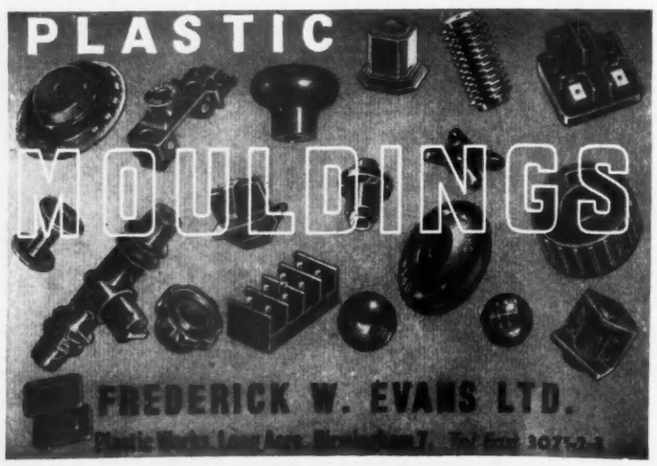

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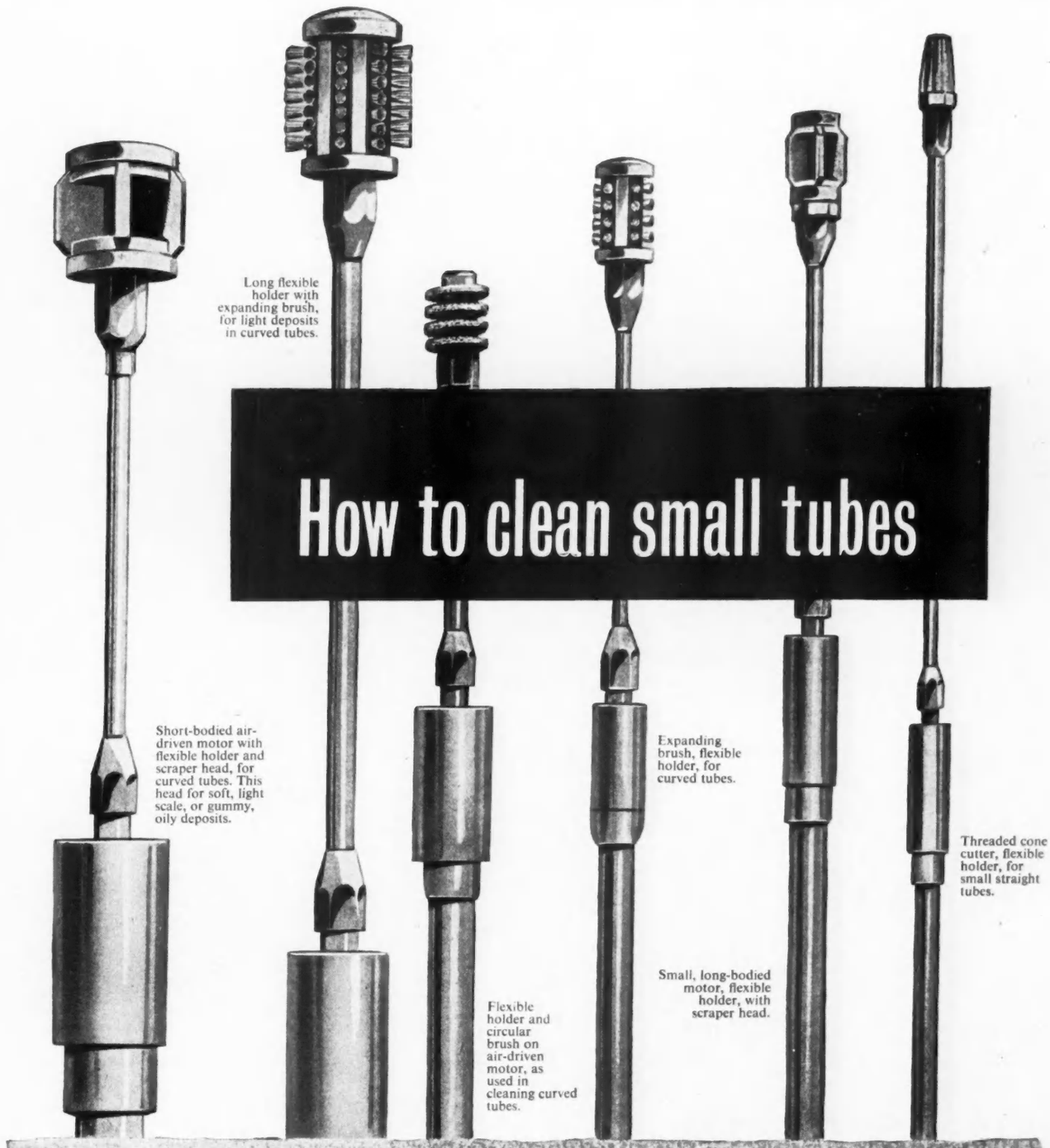
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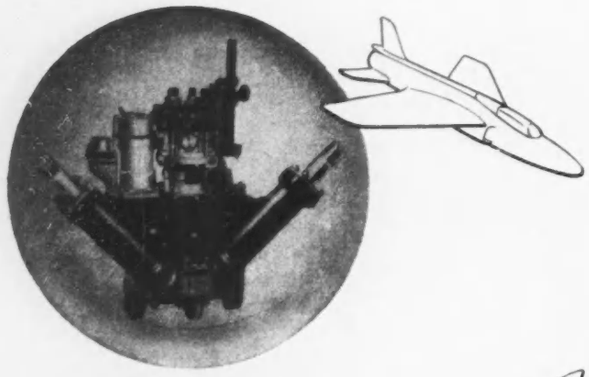

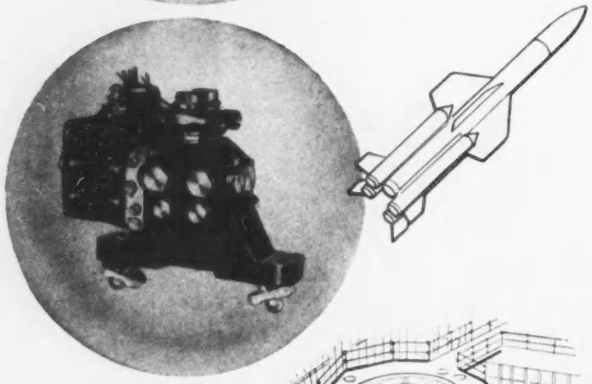

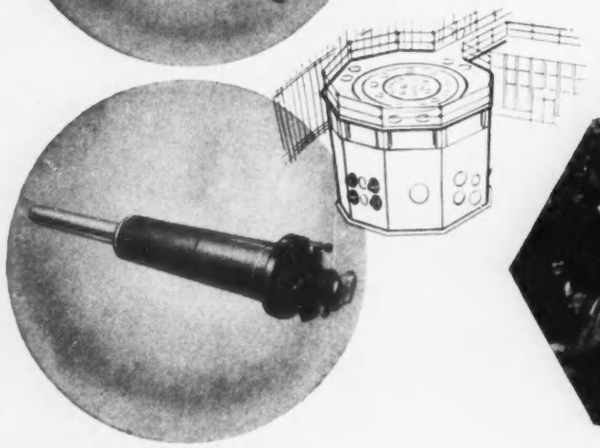

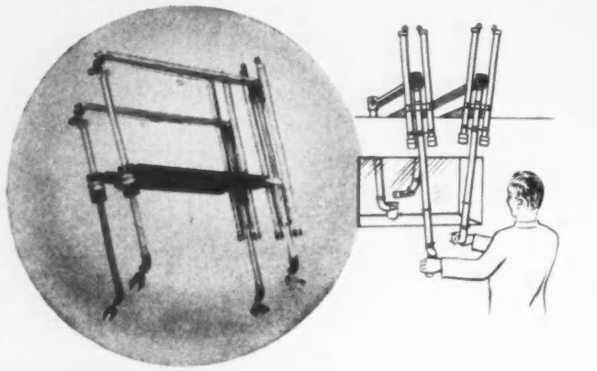

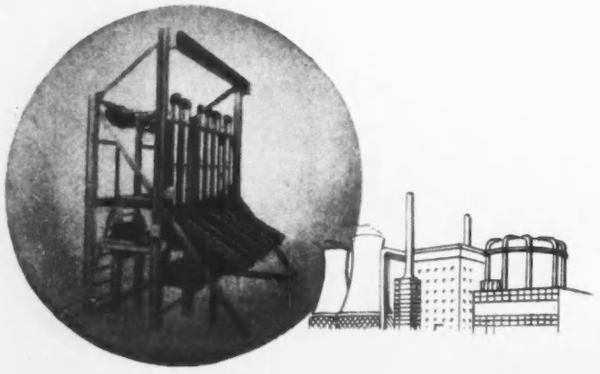

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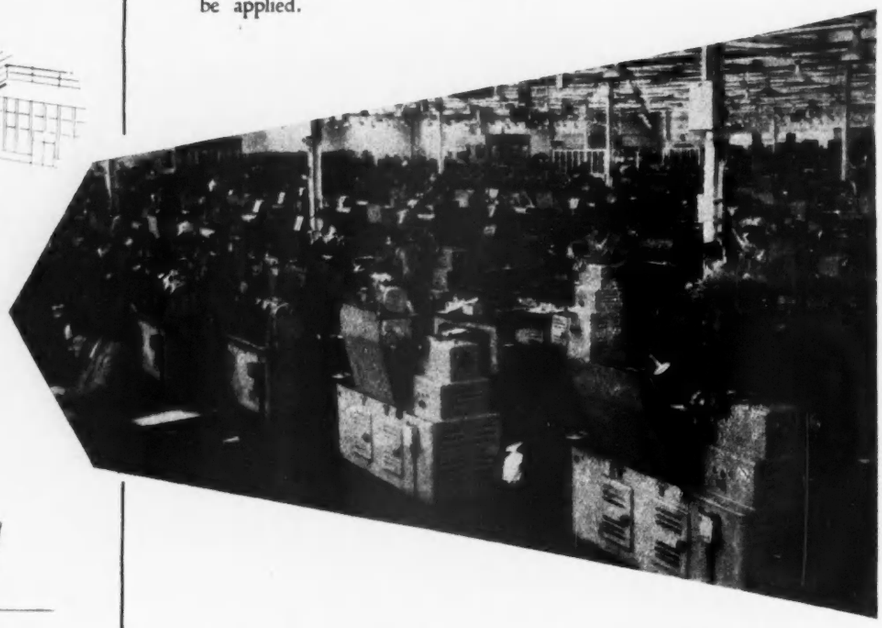

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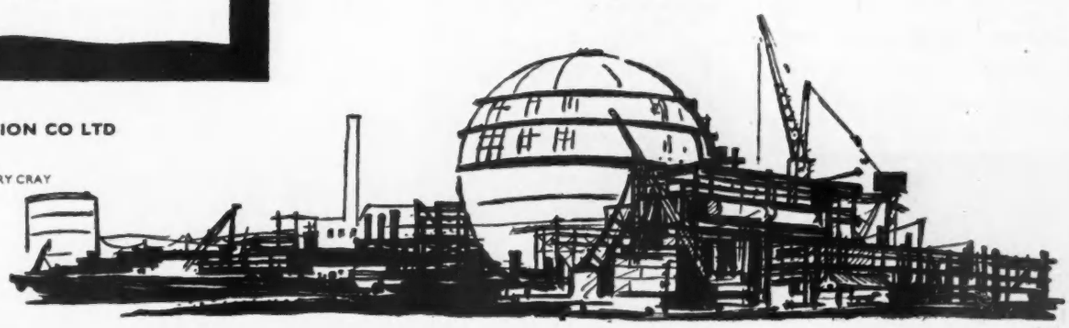

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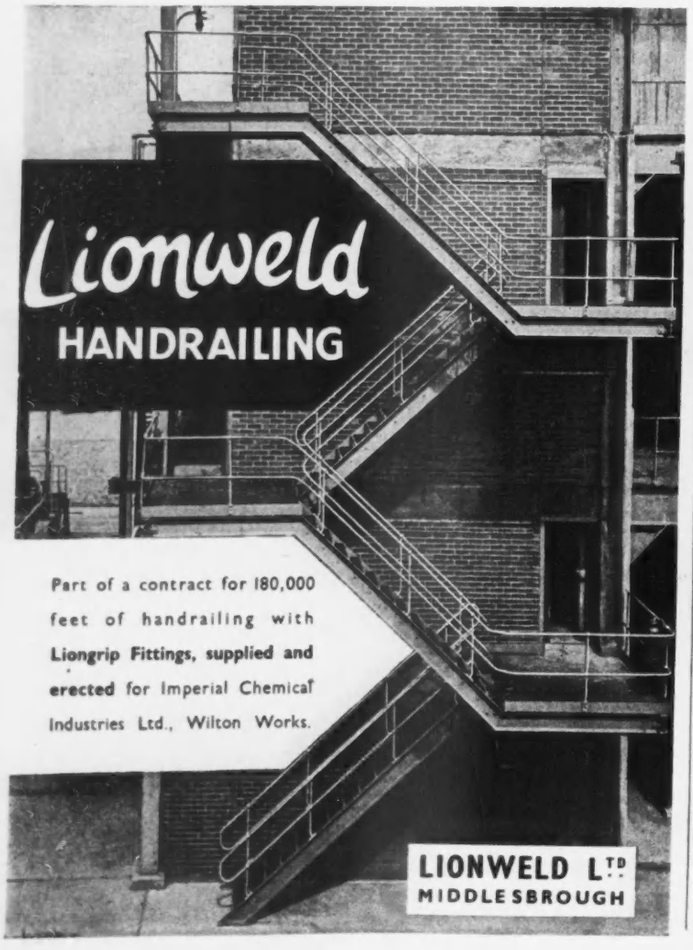
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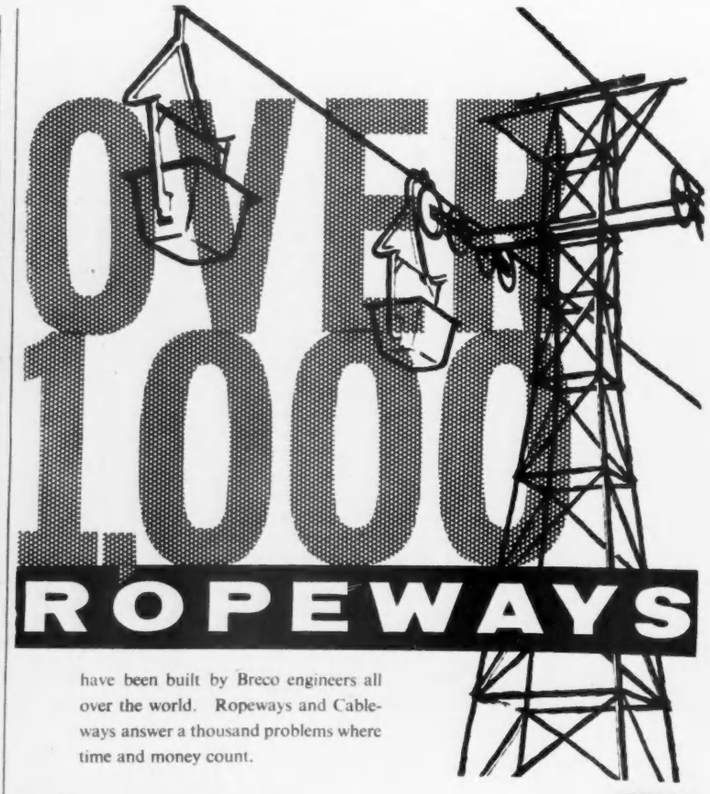

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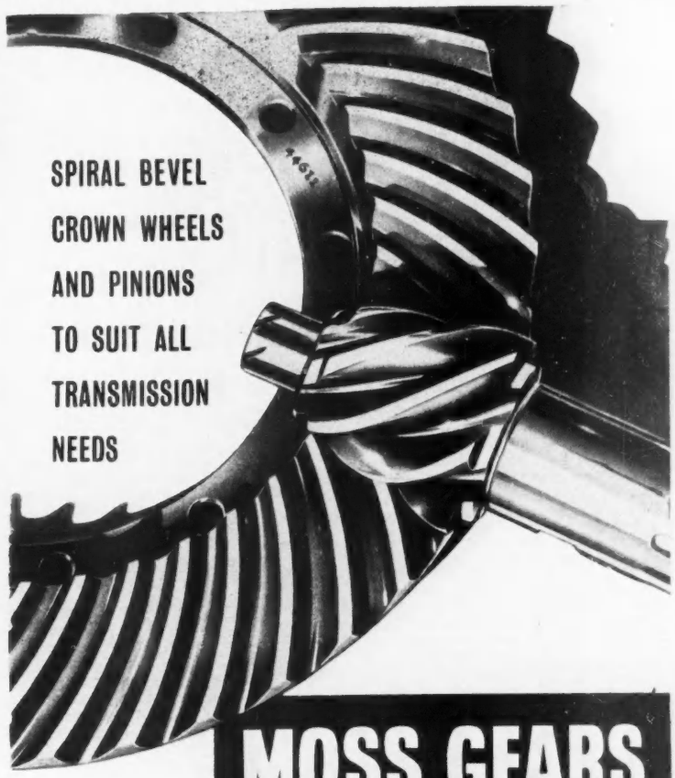

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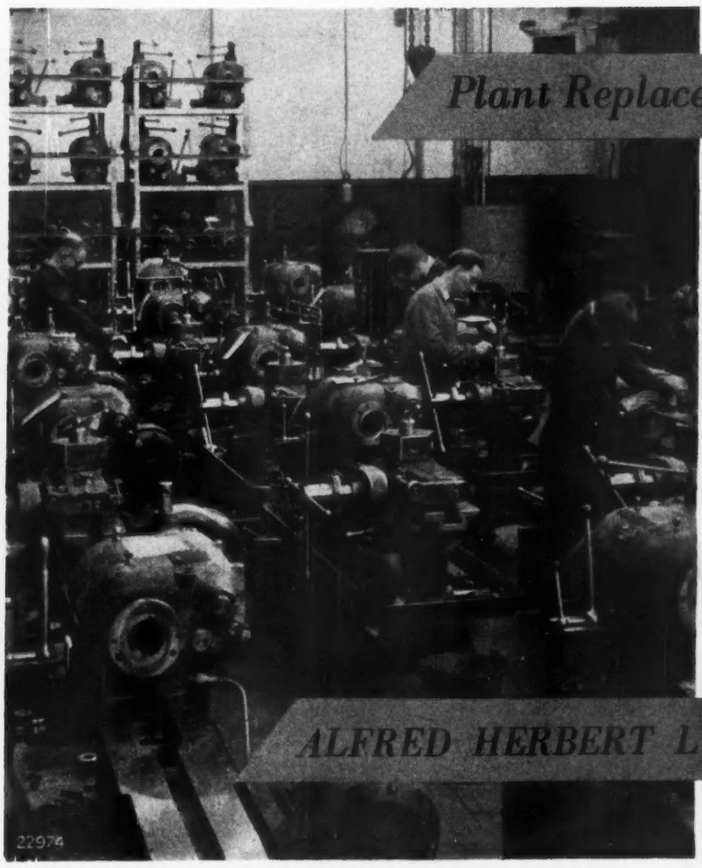

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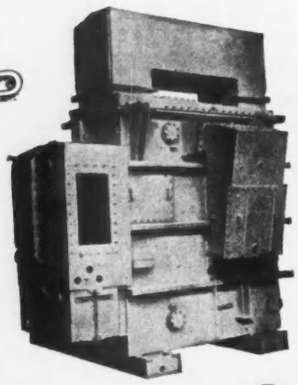

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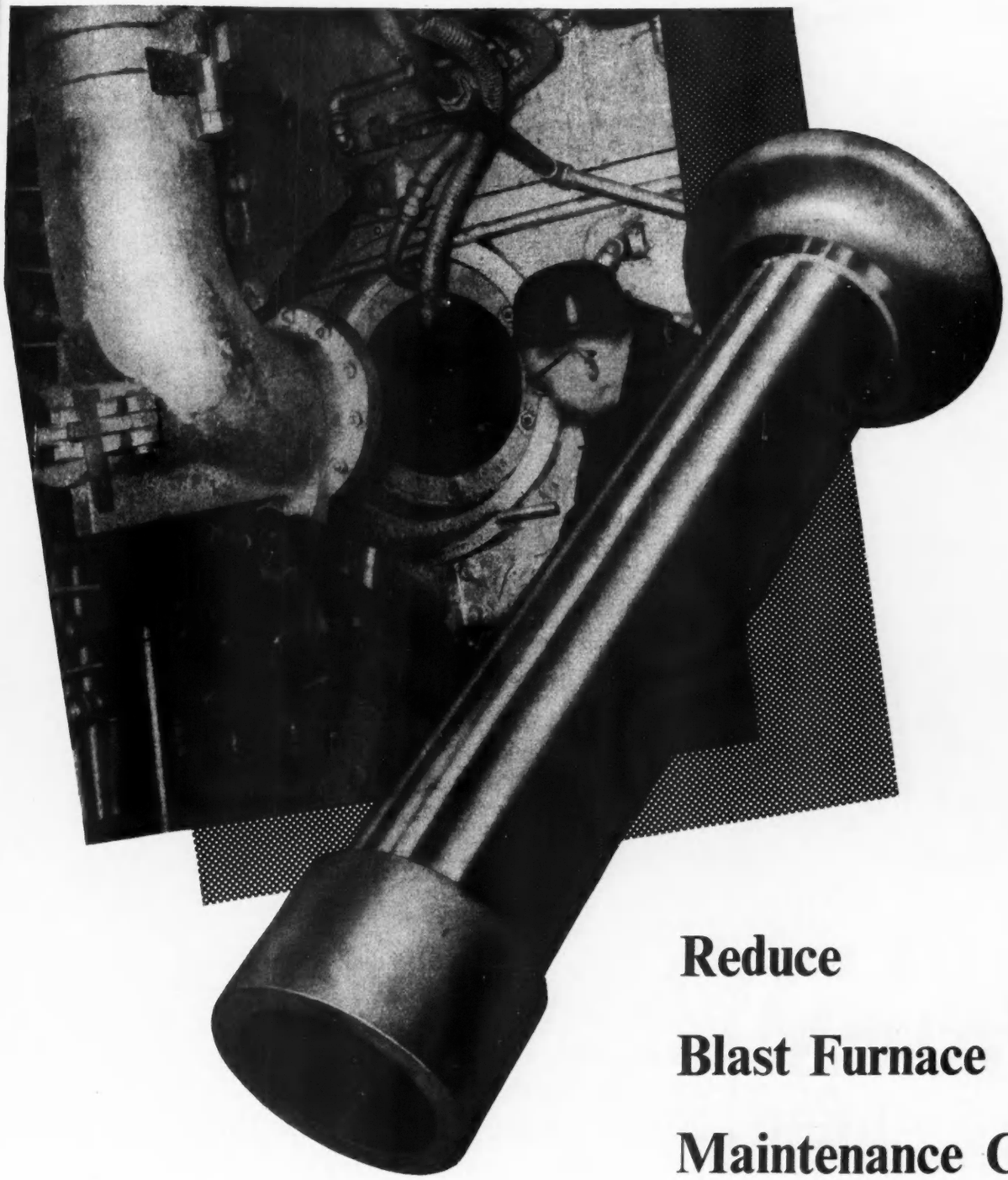

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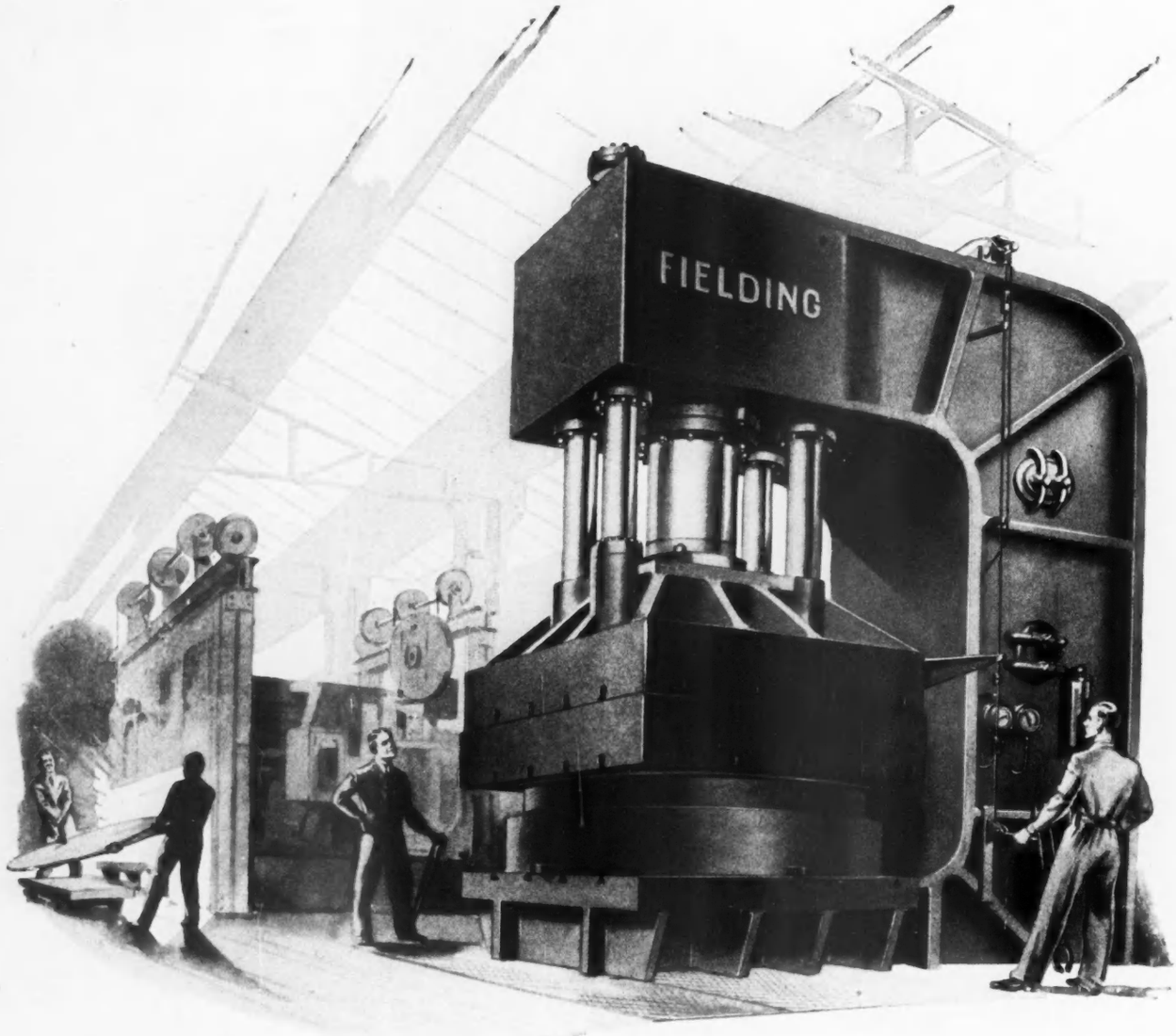

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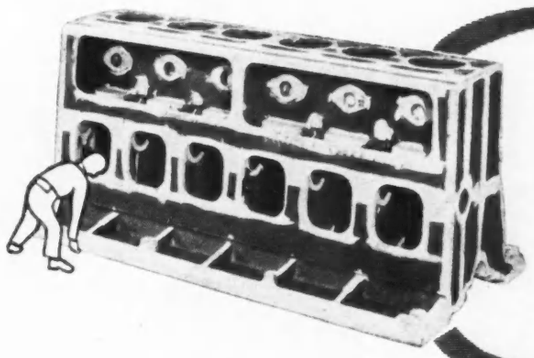

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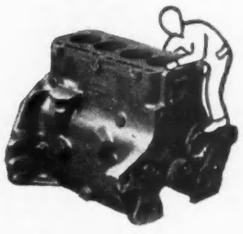

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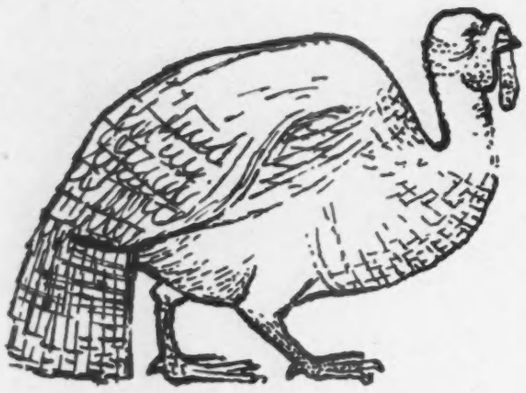

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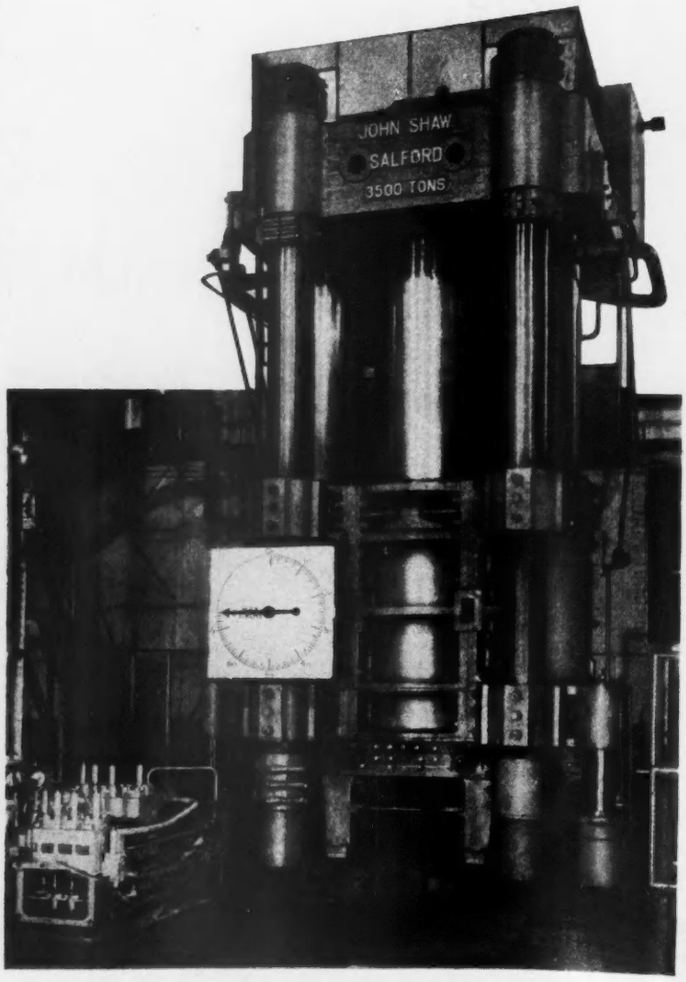

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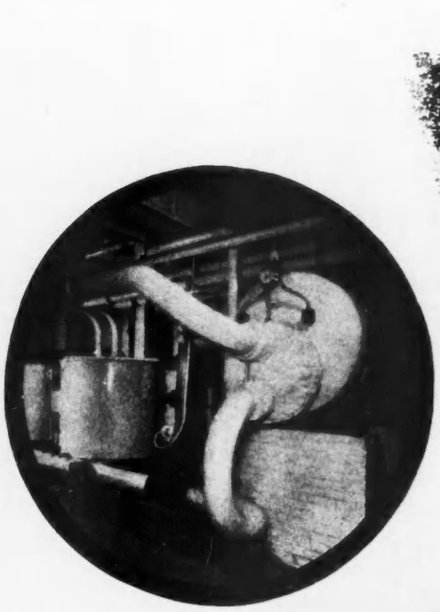

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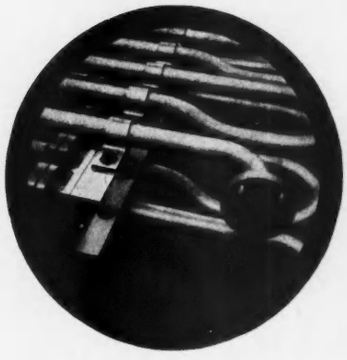

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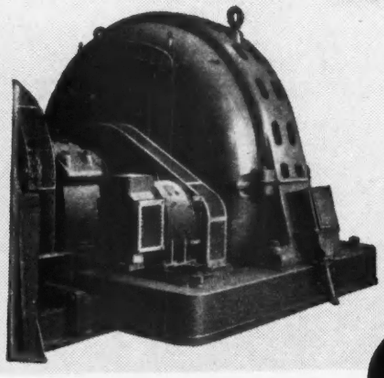

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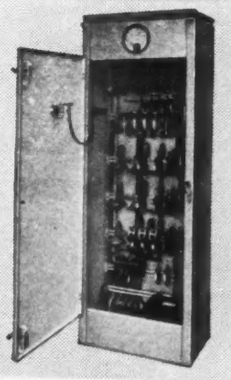

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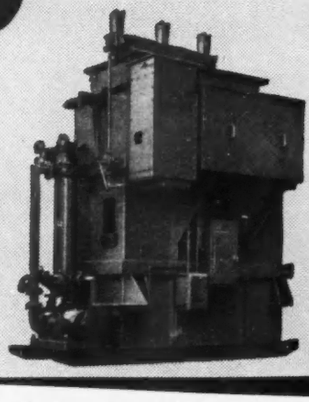

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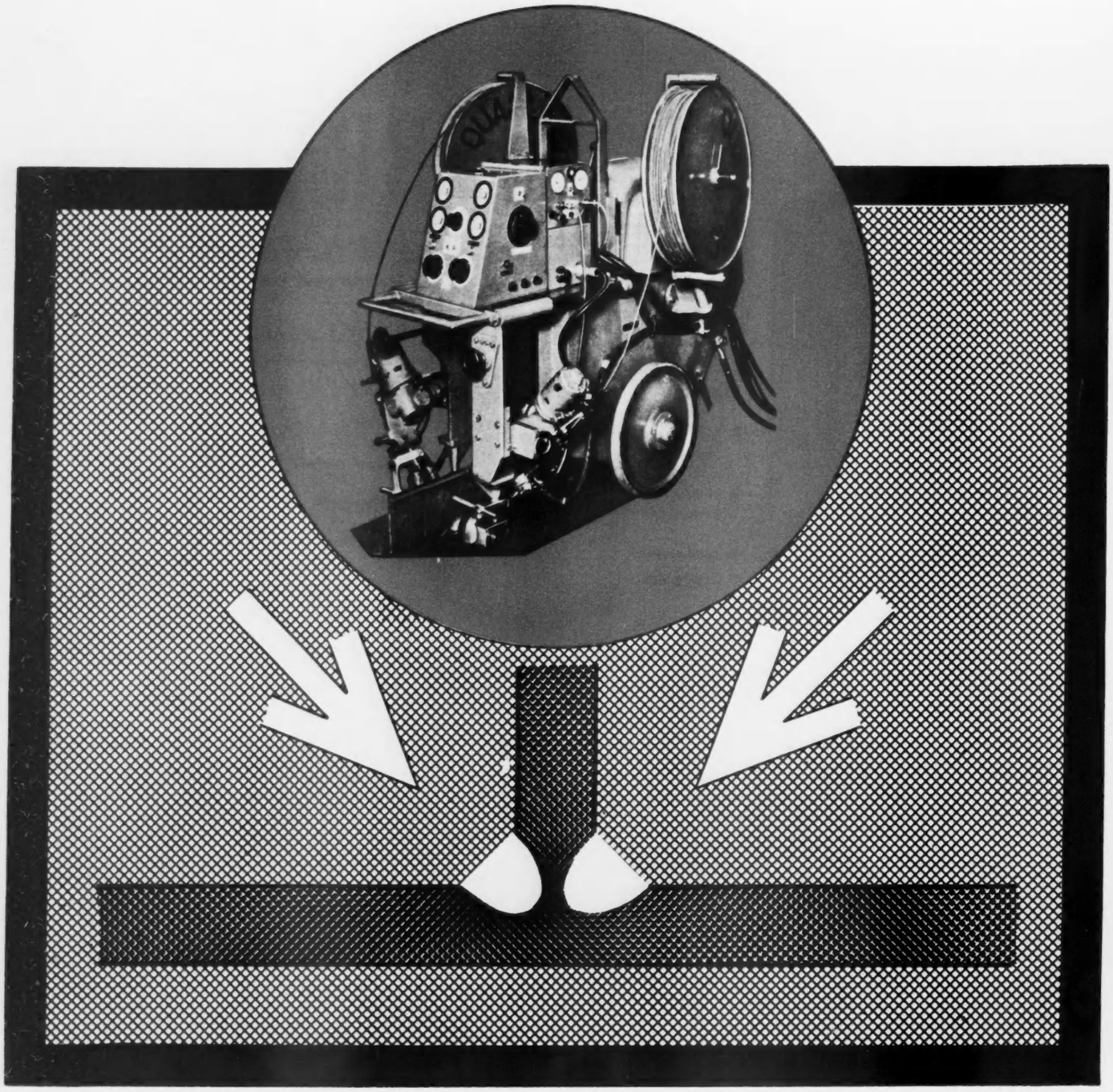

New Quasi-Arc twin-fillet welder gives another boost to production

Following the success of the automatic welding gantries, Quasi-Arc now introduce another new machine for simultaneous twin-fillet welding in shipyards or engineering works. Light, easily manœuvrable, and quickly set up, the Twin-Fillet Welder will produce 800 ft. or more of 5/16″ fillet per shift. Two FUSARC CO_2 welding heads mounted on a self-propelled carriage are *guided automatically* along the seam, giving smooth, deep-penetration welds with first-rate slag detachability.

For full details of these and many other new features write to Quasi-Arc Limited, Bilston, Staffs.

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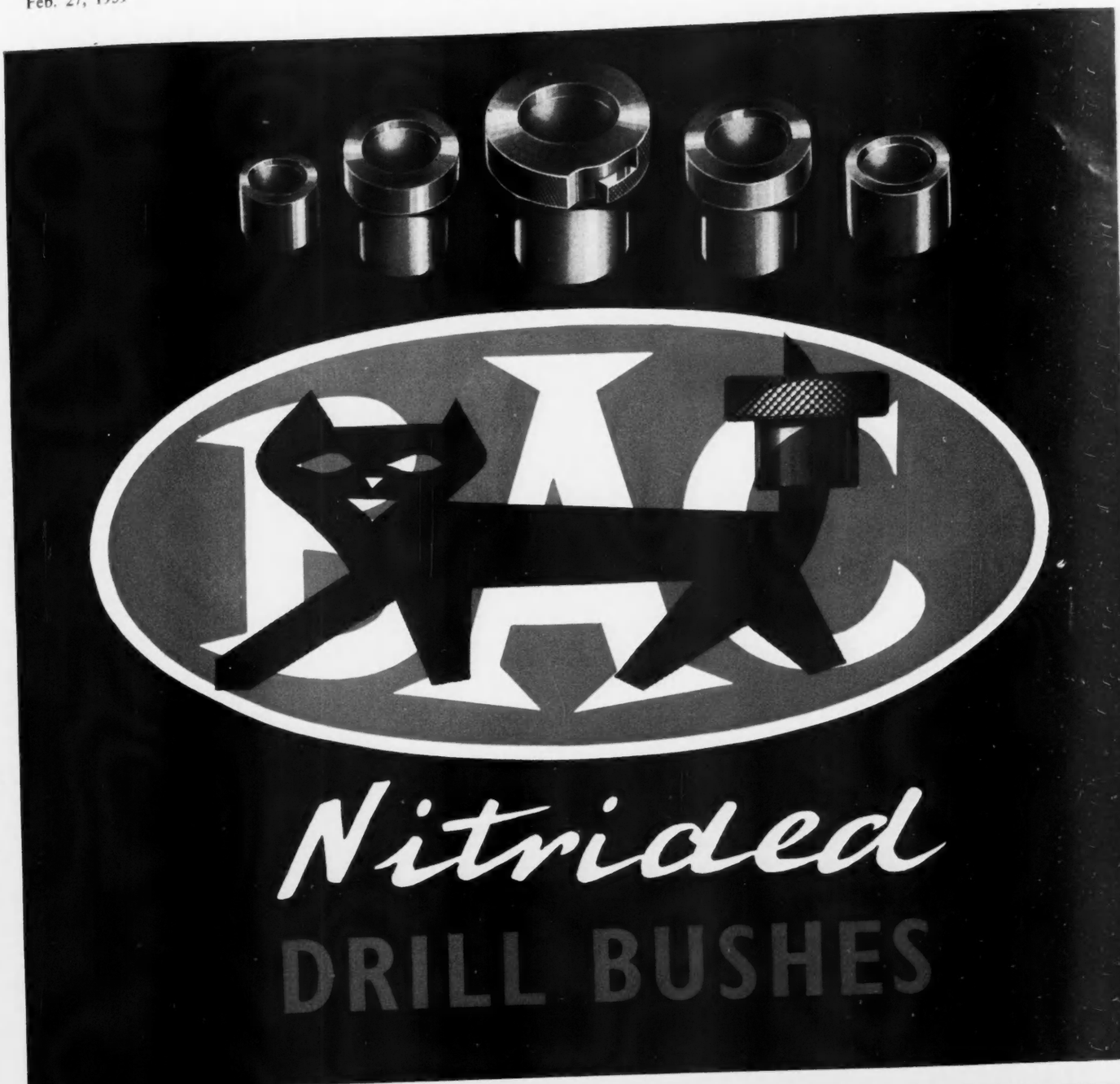
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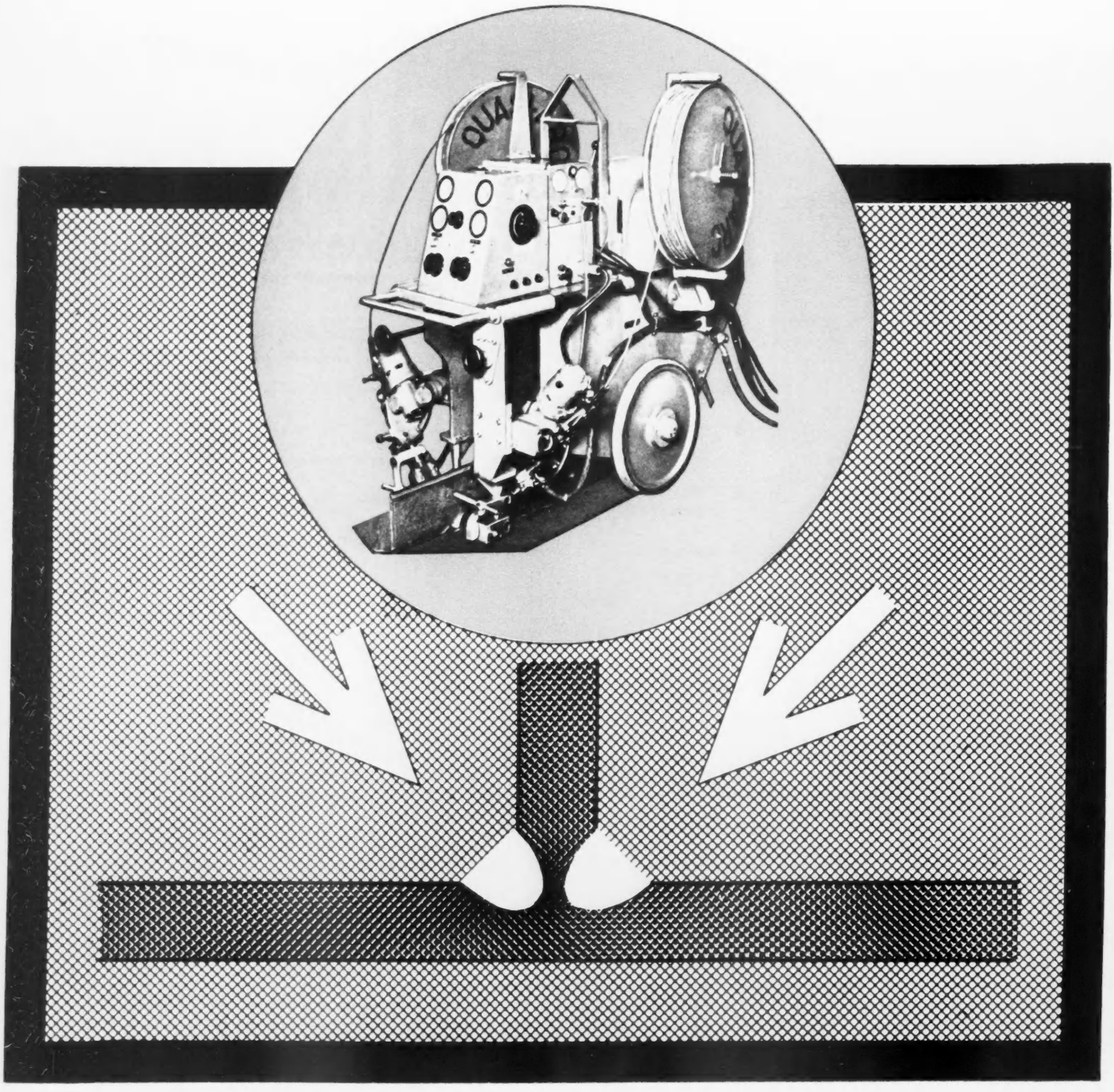

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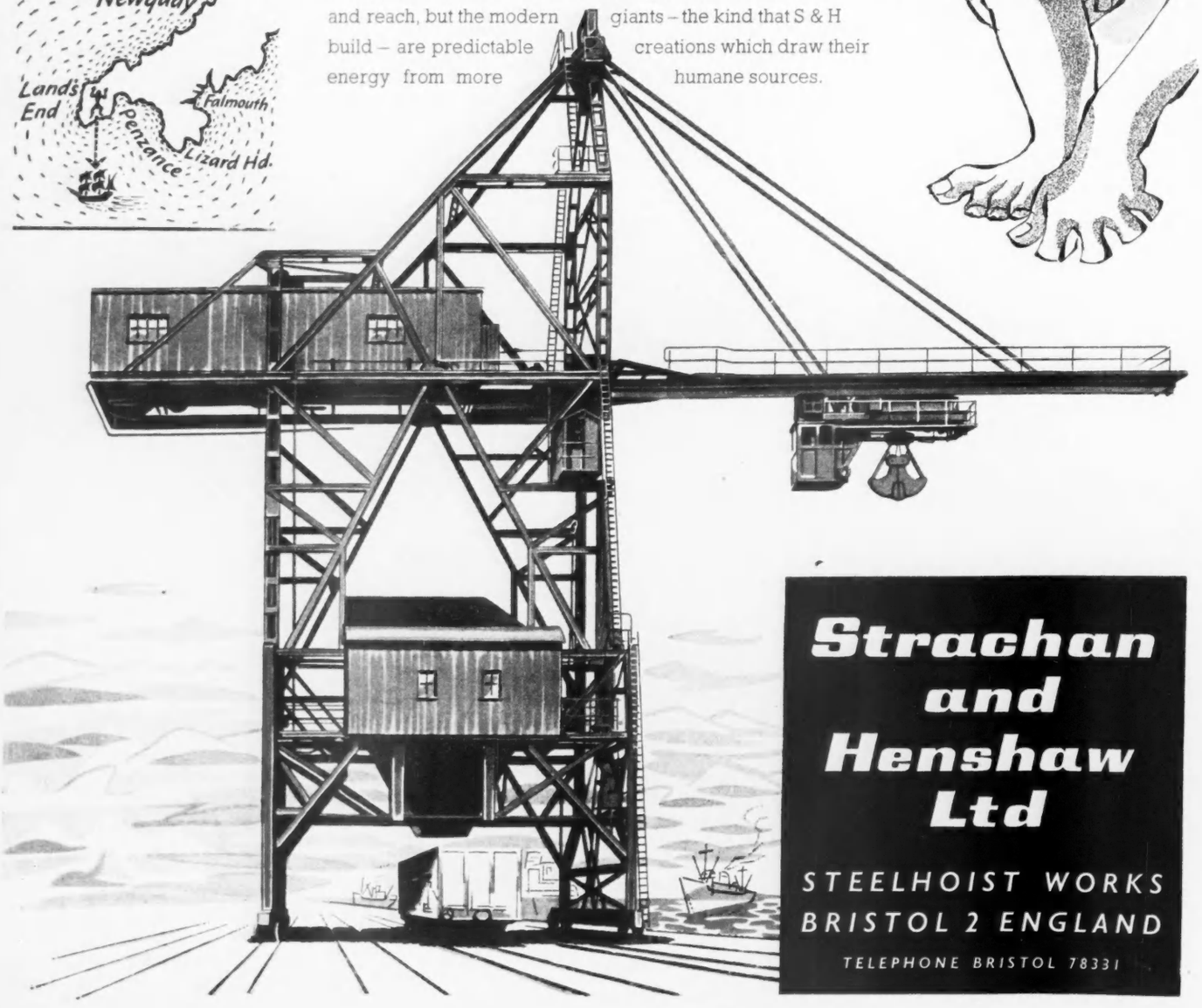

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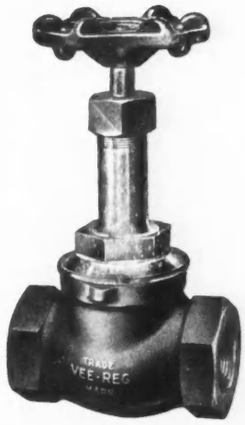

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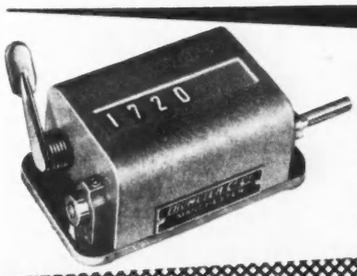

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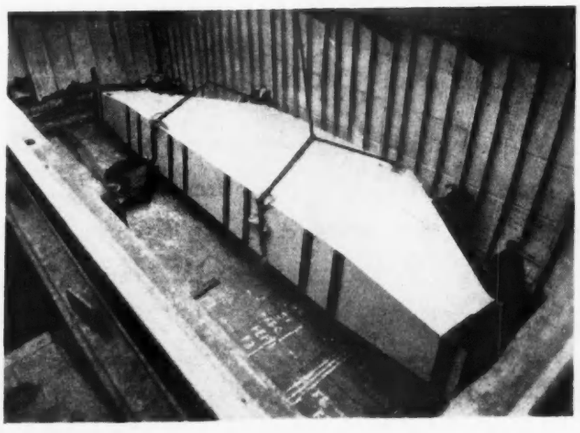

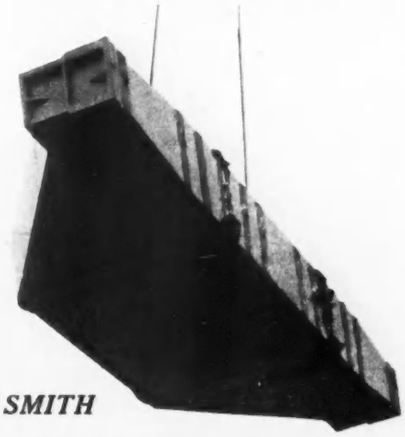

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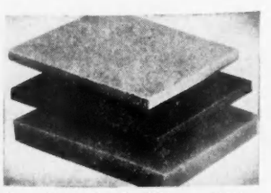

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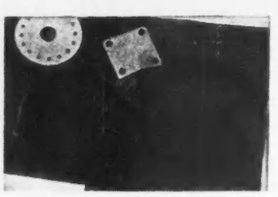

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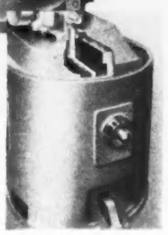

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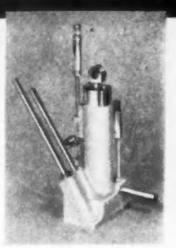

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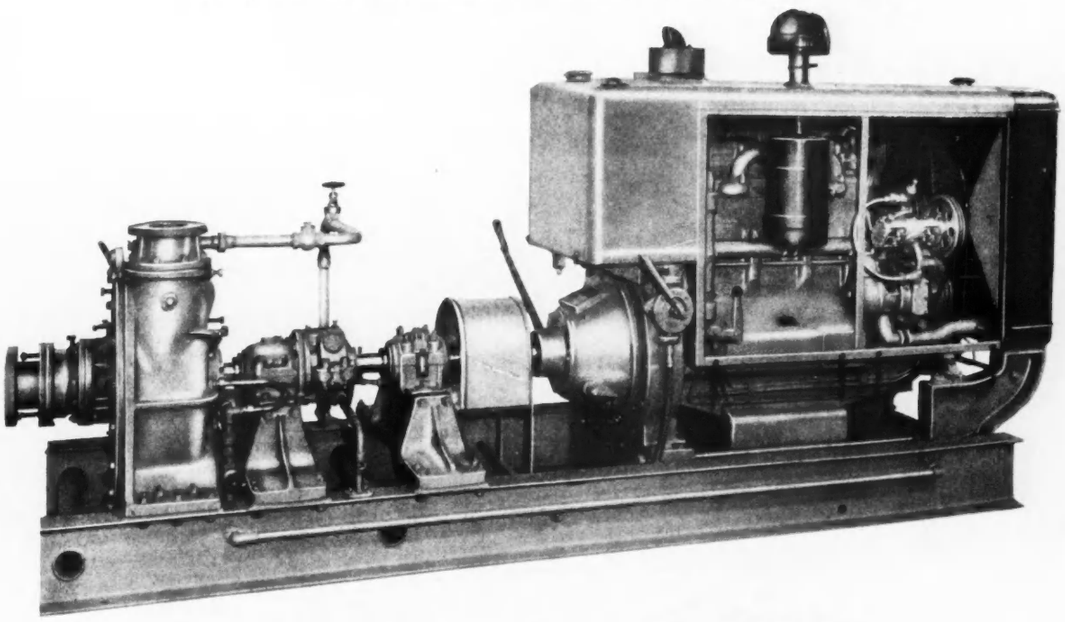

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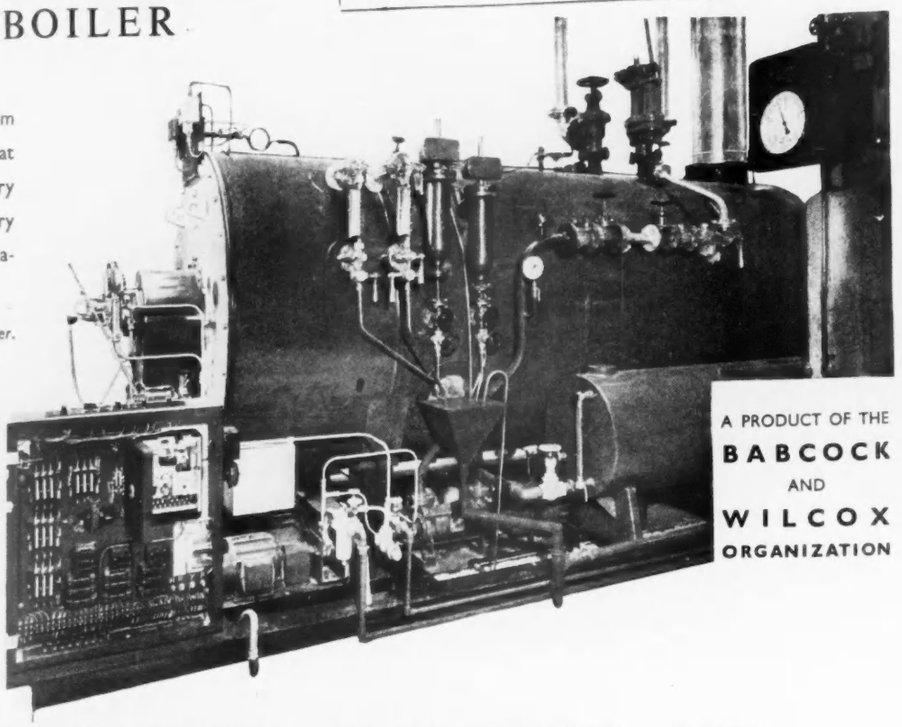

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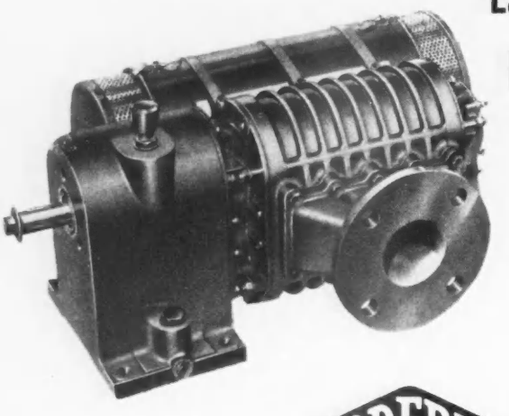

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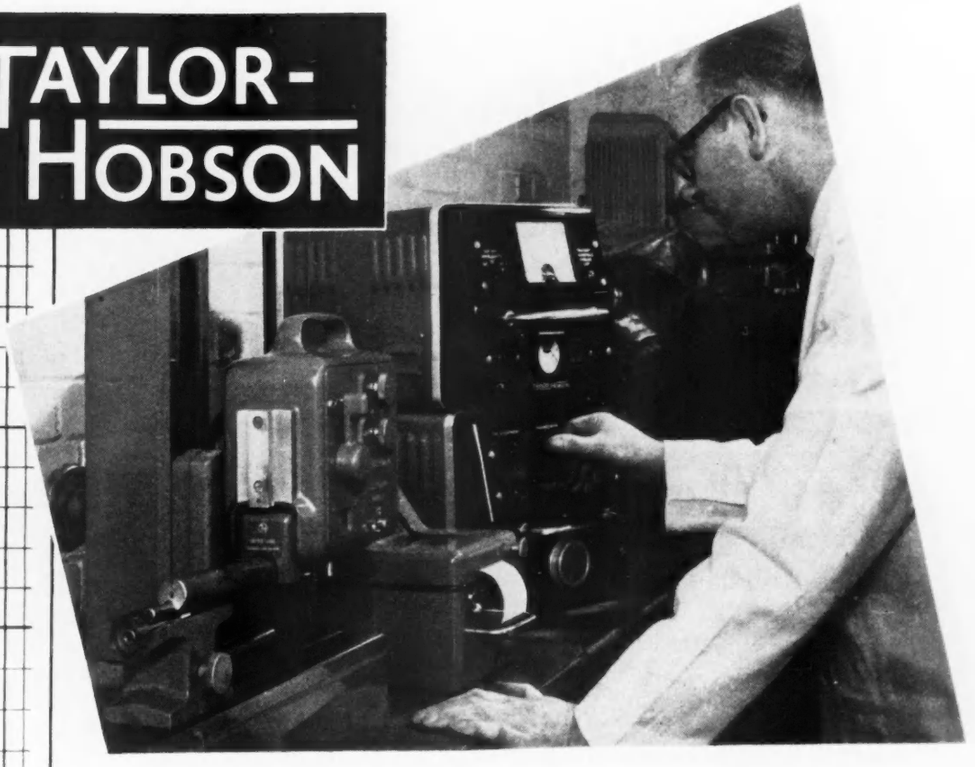
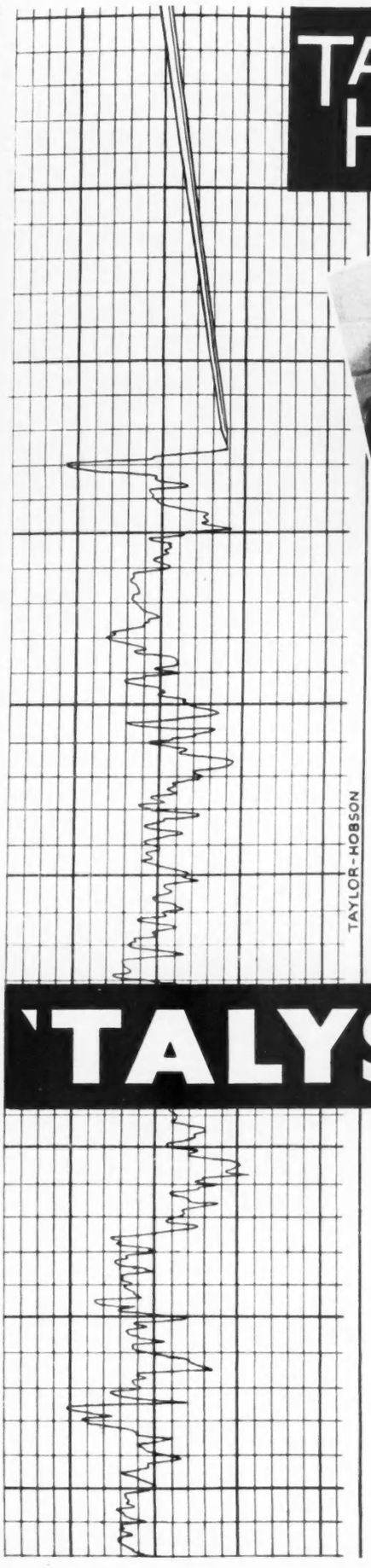




for measuring the surface texture and flatness of all moving parts in the following industries:

'TALYSURF'

BALL AND ROLLER RACE
AUTOMOBILE
MACHINE TOOLS
GAS TURBINES
GYROSCOPES
FUEL PROJECTORS
PUMPS
MISSILES
RESEARCH INSTITUTES

The illustration shows an Aircraft Feel Simulator Jack Piston being checked in Standards Room on Taylor-Hobson 'Talysurf' for surface finish of 1 to 1½ micro inch. (*Photograph by courtesy of Telehoist Ltd., an associate company of Wilmot Breeden Ltd., Birmingham 5.*)

A Division of
RANK PRECISION INDUSTRIES LTD.

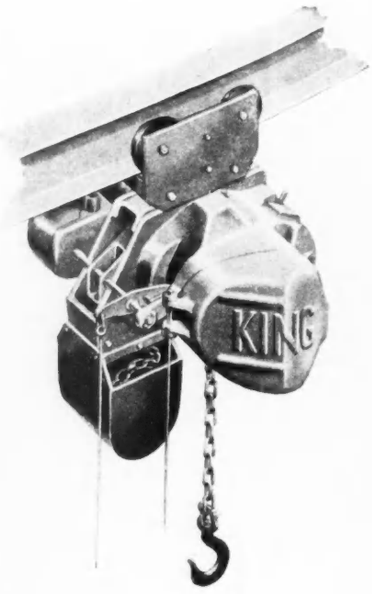
TAYLOR, TAYLOR & HOBSON, LEICESTER, England

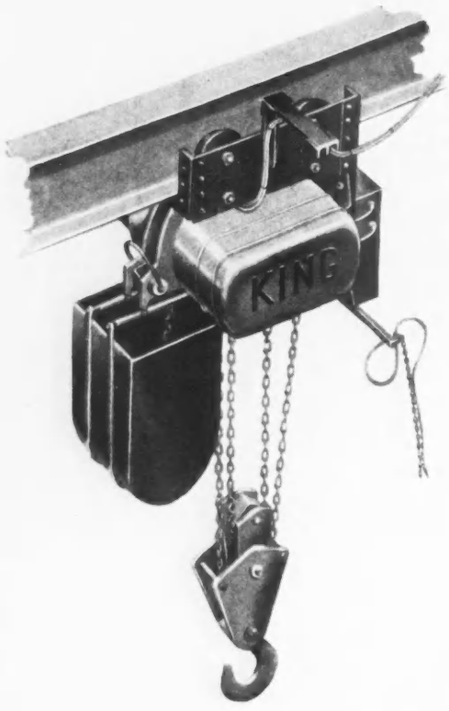
TS19

The finest hoists in the world are made by

KING

REGISTERED TRADE MARK





CAPACITIES

200 LBS. TO 13⅓ TONS

ALTERNATIVE SPEEDS AND CREEP SPEEDS *Flameproof and other special models available*

and they're made in Britain

Our representative will be pleased to call on you —anywhere in the world.

KING HOISTS & PULLEY BLOCKS

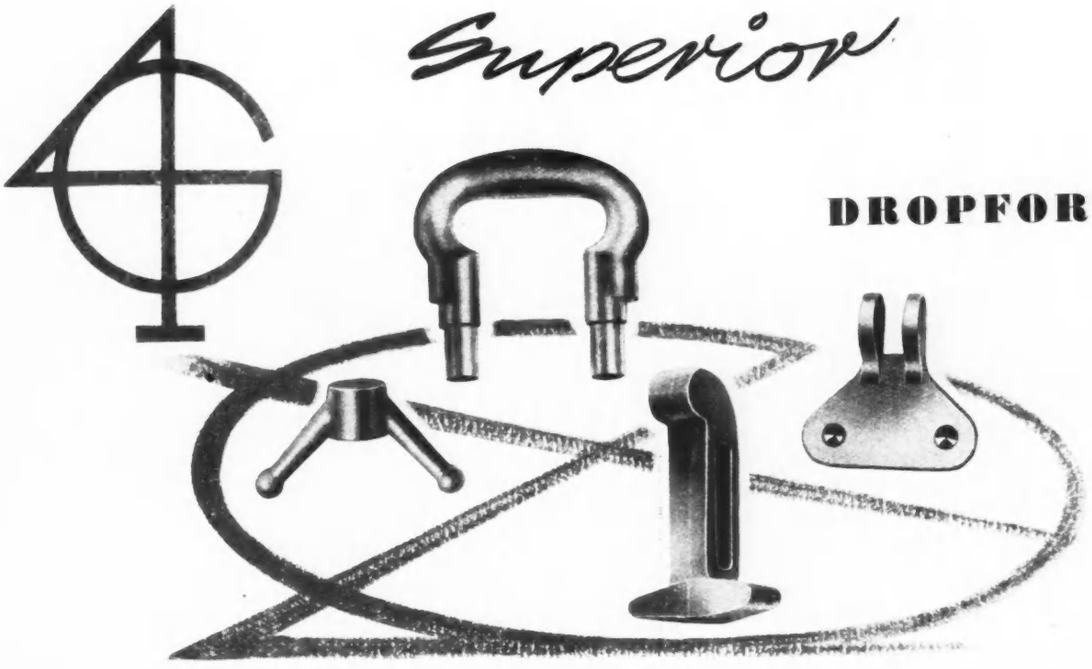
** Write or telephone for literature to:*

GEO. W. KING LTD., PB8 ARGYLE WORKS, STEVENAGE, HERTS. TEL: STEVENAGE 140

THE SYMBOL OF . . .

Superior

DROPFORGINGS



THE BLACKHEATH STAMPING CO. LTD. BLACKHEATH · BIRMINGHAM

BIG MAN... and a small back room

His name is . . . but never mind. In the Acheson Organisation we practice teamwork rather than the cult of personality. So let us merely say he works for Acheson Colloids Limited— and you. Occupation: chemist. Job: Supervisor, Sales Engineering Laboratory. Task: to solve your problems in terms of Acheson products. He has colloidal graphite (figuratively) in his veins, formulæ in his head, and feet firmly on the Lab. floor. What perhaps is dull black stuff to you is resin-bonded molybdenum disulphide and a source of infinite excitement to him. Today it is a dispersion for impregnating glass fibre heating panels; dry film lubricants to match the increasingly severe demands of the designers of supersonic aircraft and guided missiles. Yesterday it was conducting graphite coatings for postage stamps (must be non-toxic, ink-like, quick-drying, electrically conducting. They demanded). Yesterday, too, it was a silver dispersion for ocean bed cables (twenty years life, They stressed). colloidal glass for forging difficult metals, anti-corrosive coatings for nuclear power plants . . . many things, Tomorrow and tomorrow? Well, it could be *your* problem.

Acheson Colloids

LIMITED

Manufacturers of dispersions of colloidal graphite, MoS_2, silver, glass, vermiculite in suitable carrier liquids including oil, water, white spirit, alcohol etc.

ACHESON COLLOIDS LIMITED

(a subsidiary of Acheson Industries (Europe) Limited)

P.O. BOX 12 · PRINCE ROCK · PLYMOUTH · DEVON

ALSO ACHESON COLLOIDS CO., PORT HURON, MICHIGAN, U.S.A. & ACHESON COLLOIDEN N.V. SCHEEMDA (GR) NETHERLANDS

N

LOCOMOTIVES

Designers and Builders of Steam, Diesel and Diesel-electric and Battery Locomotives for all purposes. Flame Proof Diesel and Battery Locos for underground working.

HUDSWELL, CLARKE & COMPANY LIMITED

Railway Foundry, Leeds

LONDON OFFICE:
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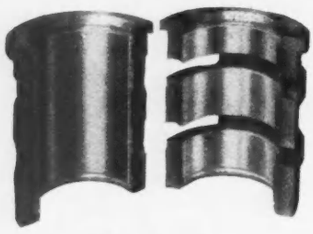
TELEPHONE:
Victoria 6786

WHITE METAL BEARING RECONDITIONING



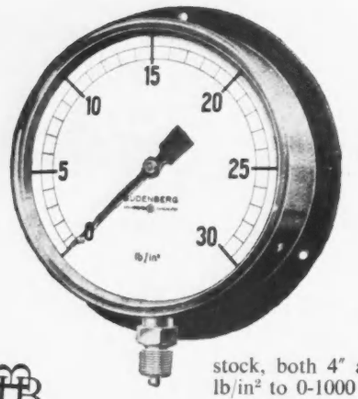
Enquiries please to:

Wheatley & Whiteley

99, Kirkstall Rd., Leeds, 3 Tel. 31122

Budenberg

BRONZE TUBE PRESSURE GAUGES from stock



We have a complete range of gauges in stock, both 4″ and 6″ dial, from 0-15 lb/in² to 0-1000 lb/in²; these are fitted in a brass case with back flange for surface mounting and with pressure connection screwed ⅜″ B.S.P.
Also in our stock we have a big selection of other gauges to suit most industrial applications and a four-page stock folder, which gives full details, will gladly be sent on request.

Budenberg

BUDENBERG GAUGE CO. LTD. BROADHEATH Nr. MANCHESTER

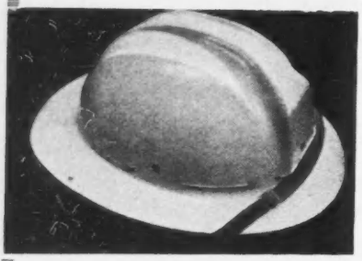
dmBU45

Keep ahead in safety . . .

with the eversafe

Everoak

SAFETY HELMETS



EVEROAK Safety helmets are manufactured under British Standard Licences—your guarantee of a first-class safety product.

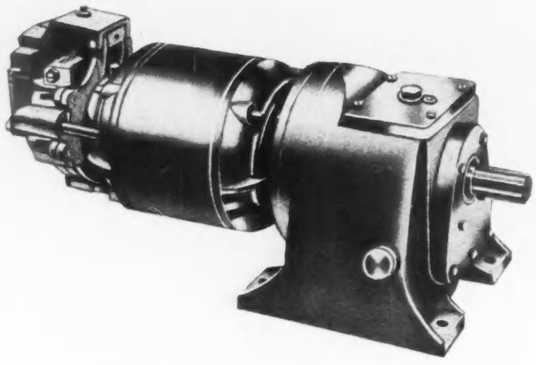
PRICE 17/6 EACH

EVEROAK gives complete head protection for those working in: Quarries, Mines, Building Sites, Ship Yards, Refineries, etc., etc.

AVAILABLE IN VARIOUS COLOURS. WRITE FOR FULL DETAILS TO:

EVERITT W. VERO & CO. LTD

EAST DULWICH ROAD · LONDON S.E.22



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Standard and Flameproof.

GEARED MOTORS WITH ELECTRO-MAGNETIC BRAKES

GEARED MOTORS.
SPEED REDUCERS.
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WORM GEARED MOTORS.
CONTRA-ROTATING G/BOXES.
VARIABLE SPEED UNITS.

FLANGE MOUNTING GEARED MOTORS
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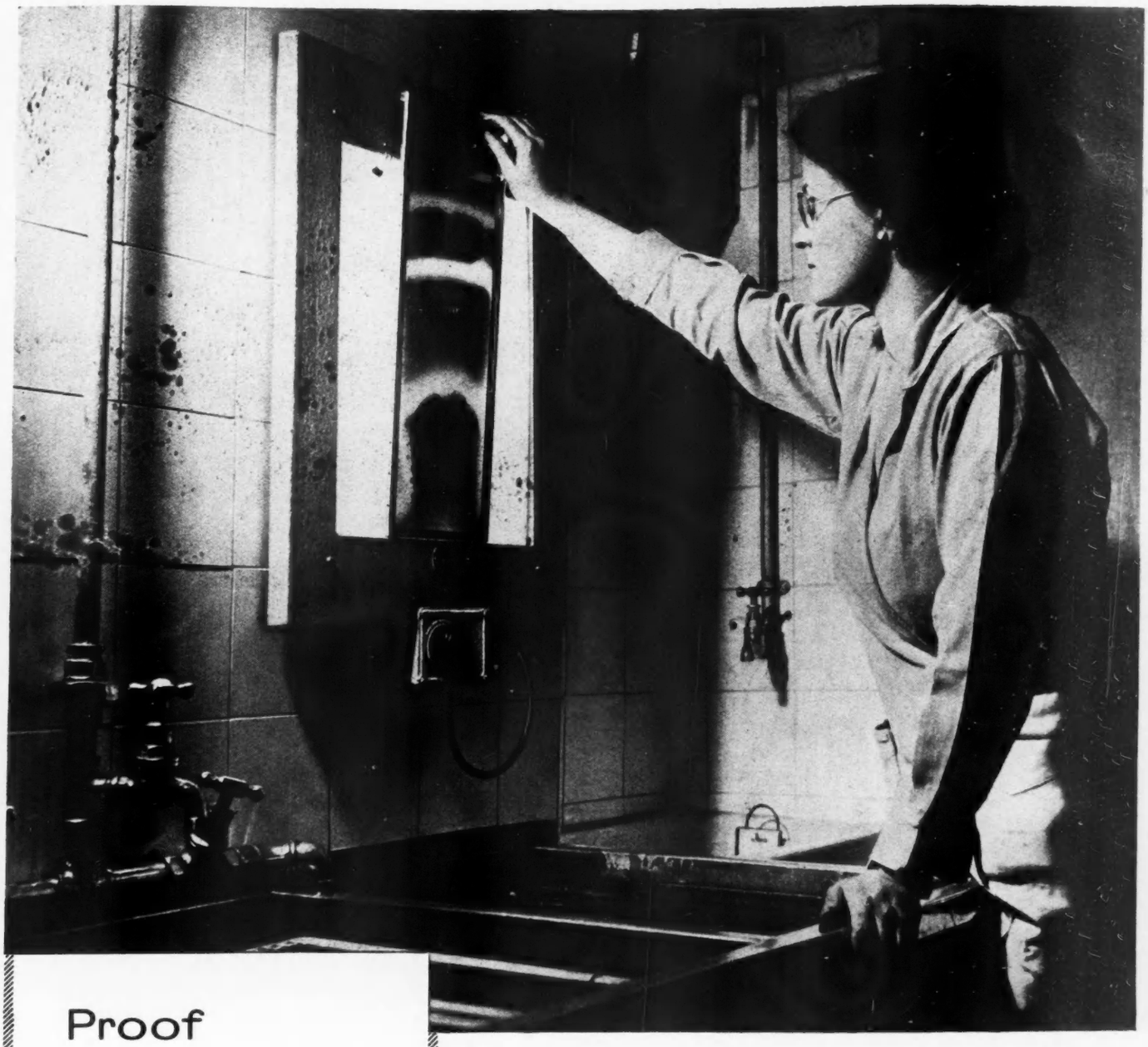
1/10 to 300 h.p.

Electropower Gears Ltd

KINGSBURY WORKS, KINGSBURY ROAD, LONDON, N.W.9. PHONE: COLINDALE 4621-3 GRAMS: LEKTROPOWA, HYDE, LONDON



Proof negative

Aluminium alloys are complex materials, and casting presents problems which must be solved by specialists in the foundry itself. For the production of castings of consistent quality, scientific control is essential. Our chemical and physical laboratories are provided with equipment of the most up-to-date type, by which the output from our foundries is continually checked for conformity to specification and mechanical excellence.

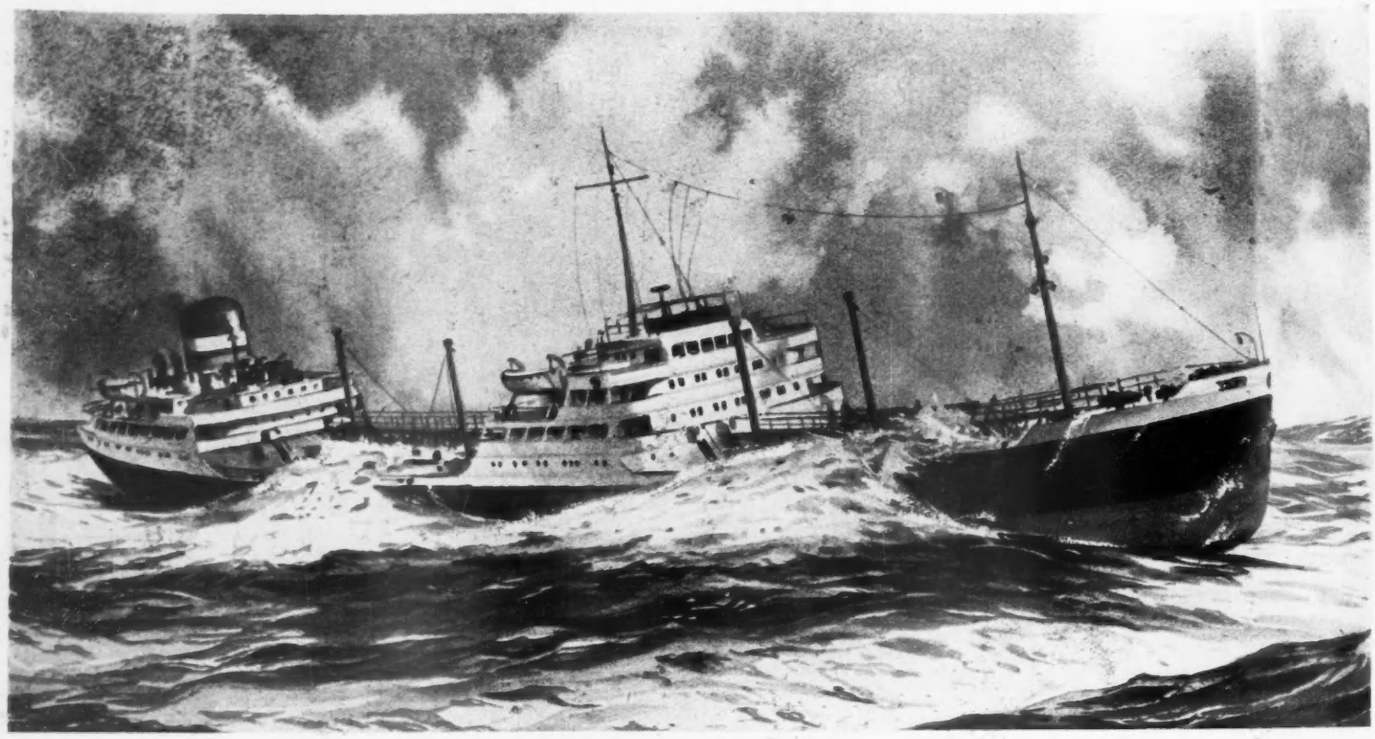
Sand cast aluminium alloy air intake casting for the Bristol 'Proteus' propeller turbine.

William Mills Limited

FOUNDERS IN ALUMINIUM ALLOYS

SAND CASTINGS GRAVITY DIE CASTINGS PRESSURE DIE CASTINGS | FRIAR PARK FOUNDRY, FRIAR PARK ROAD, WEDNESBURY, STAFFS.

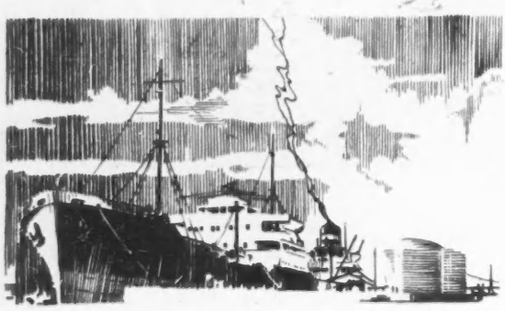
AP119



A **Weir**

CLOSED FEED SYSTEM

is stable under all operating conditions

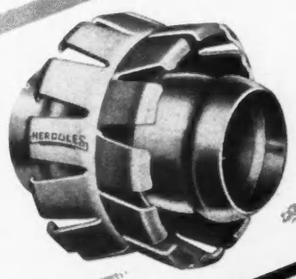


Feeding pure water to the boilers, free from corrosive gases, it is efficient, reliable and entirely automatic in operation. A Weir sea-water evaporator in the system supplies all the ship's fresh water for boiler feed and domestic purposes. The Weir auxiliaries built into the system have more than seventy years of design and manufacturing experience behind them.

Weir CLOSED FEED SYSTEMS ARE INSTALLED IN MANY HUNDREDS OF SHIPS OF ALL NATIONS

G. & J. WEIR LTD. · CATHCART · GLASGOW S.4

What's so Special about HERCULES Hose fittings?



Several features put Hercules Fittings in a class by themselves. For example, their special Claw Grips are securely fixed simply by hammering down. They are simple to apply —need NO clips, clamps or wires. They cut replacement costs, eliminate pressure losses, are safe in use. How's that for strength, simplicity and money-saving economy ?

Hercules Repairers, Screw Couplings, Adaptors, etc., for pneumatic, oxy-acetylene and all industrial hose.

New lug-type Couplings for suction and delivery hose, in brass, gun-metal or stainless steel.

HERCULES SIMPLY HAMMER IT

GIVE YOU THE RIGHT CONNECTION

NEWTON SALES COMPANY LTD

(Industrial Division), 517, Fulham Road, London, S.W.6. Tel: FULham 4228

THE SPECIALISTS IN HOSE FITTINGS

ONE MINUTE! TO CUT A MILD STEEL BAR THIS SIZE

WITH THE

2" × 3/16" —10 secs.

1" × 3/16" —3 secs.

"Voucher-57" PNEUMATIC SAW MACHINE

CAPACITY 2¼in. OR 3in. BARS OR TUBES

Dead Square Cut. No Work Hardening. No Dust. No Fraze.
Fixed or Variable Speeds.
Fixed Work Position for Rigid Control.
The Work is Gripped on Both Sides of the Saw Blade, Waste Ends Eliminated.
Fully Automatic Machines with Magazine Feed for Short Lengths.
Semi-Automatic Machines for Long Lengths.

We can also offer standard or special purpose machines for screwing or cutting-off or both. May we quote you?

Write for descriptive leaflet E.2, or call at our Works for a demonstration.

VOUCHER LTD., ESSEX TERRACE, INTOWN, WALSALL, STAFFS.
Telephone: WALSALL 2759 & 3396

THIS FOR THE NEW PLANT? S·K·

C

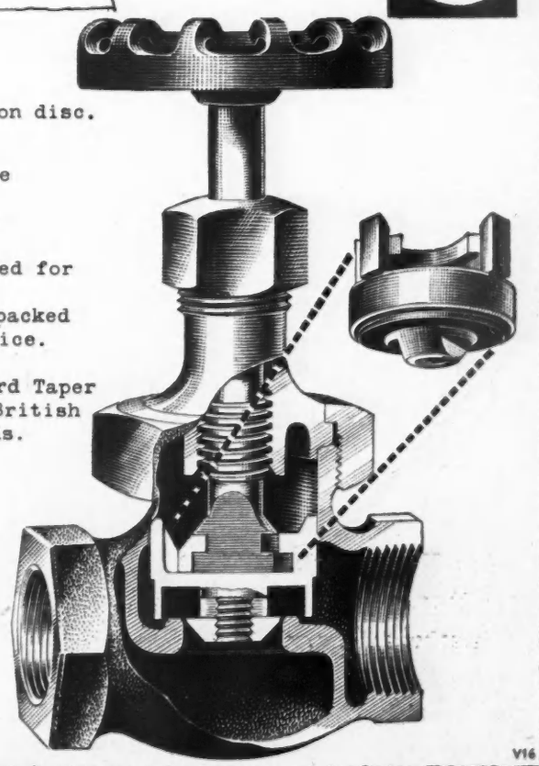
BULLETIN ON CRANE BRONZE GLOBE VALVES

...featuring the D7 with renewable disc holder and composition disc.

The renewable disc holder of the D7 makes it possible for the engineer to renew the disc on any size valve in this wide range quickly and easily. The replaced holder can afterwards be fitted with a new disc at the engineer's convenience. This valve is made to British Standard 2060 and is recommended for steam and hot water lines, and cold services such as water, oil, gas or air. When wide open, the valves can be repacked under pressure. They can be specially packed for petrol service.

Screwed or Flanged patterns available. Screwed British Standard Taper Threads—or to American Standards. Flanged in accordance with British Standard Tables 'D', 'E', 'F' or 'H'—or to American Standards.

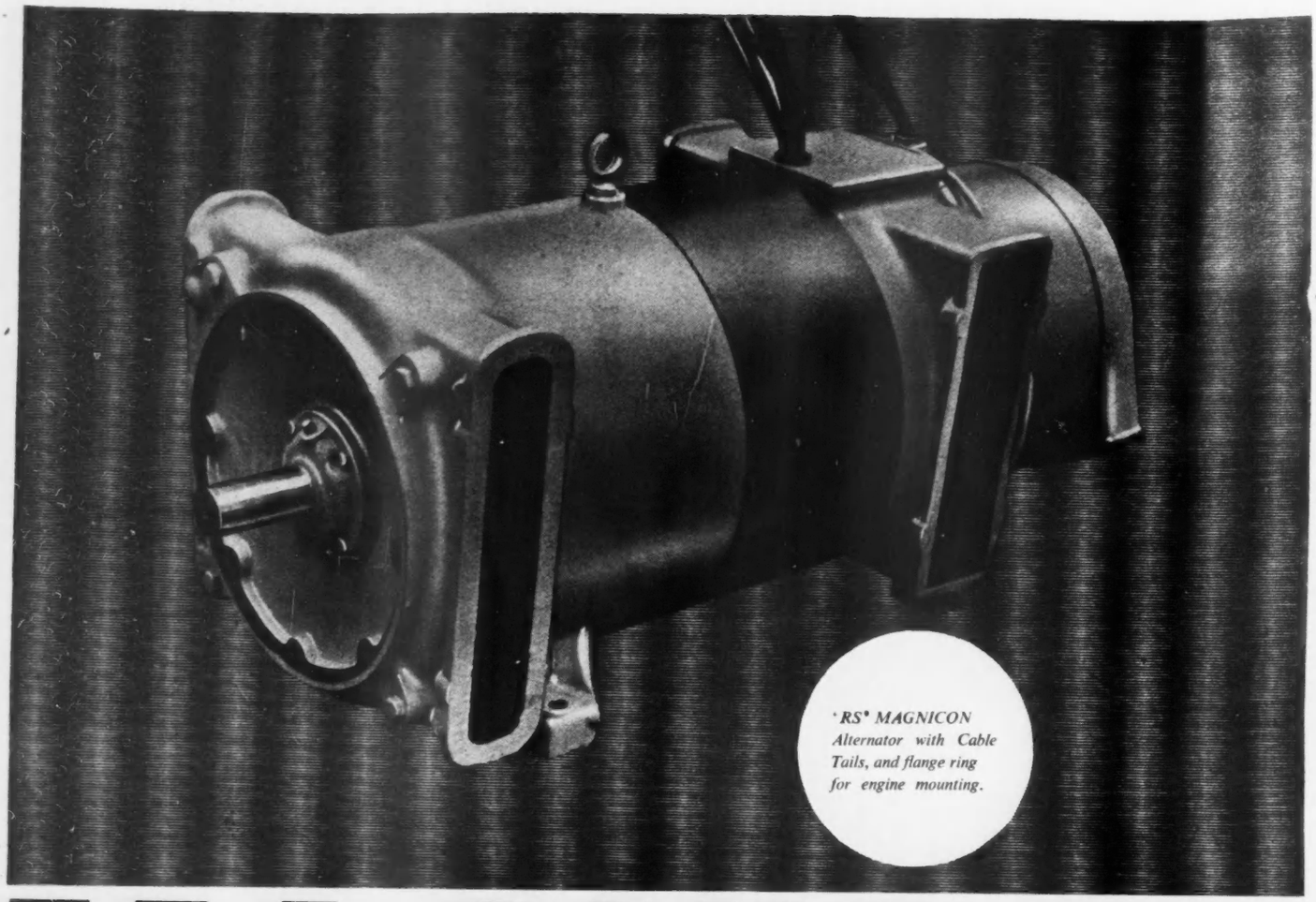
Working pressures: (valves with screwed ends) saturated steam up to 200 pounds. Cold services up to 400 pounds.
Sizes: Screwed—¼" to 3"; Flanged—½" to 3".
Sizes 2½" and 3" have a bolted bonnet.



CRANE VALVES OF BRONZE CAST IRON AND CAST STEEL

CRANE LTD., 15-16 RED LION COURT, FLEET STREET, LONDON, E.C.4. WORKS: IPSWICH
Branches: Birmingham, Brentford, Bristol, Glasgow, London, Manchester

V16



'RS' MAGNICON Alternator with Cable Tails, and flange ring for engine mounting.

MAGNICON

inherent self-regulation in the lower output range

The 'RS' Range of MAGNICON Alternators has been produced to meet the current and growing need for a competitively priced Self-regulating Alternator in the lower output range giving full MAGNICON performance with an inherent voltage regulation within $\pm 2\frac{1}{2}\%$ as standard.

Manufactured to the latest issue of B.S.2613 for class E insulation.

Full information available on request.

Ask for Leaflet A58.

THE MACFARLANE ENGINEERING CO LTD
Netherlee Road Cathcart Glasgow S 4
Telephone Merrylee 2255-7

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.
Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch.
There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g. ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.
Inch Rate. 42/- per single column inch and *pro rata*. 12 lines to 1 inch.
There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g. ¼-page £22. ½-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.
Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.
Use of Box Number. 2/- which includes forwarding of replies.
Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565

PUBLIC APPOINTMENTS

ROYAL MILITARY COLLEGE OF SCIENCE, SHRIVENHAM, BERKS

LECTURERS OR SENIOR LECTURERS

Posts for men as LECTURERS or SENIOR LECTURERS (according to age, qualifications and experience), to teach at University level in Mathematics (2 posts); Physics (1 post); Civil Engineering (2 posts); Surveying (1 post—Senior Lecturer); Mechanical Engineering (2 posts); Radar and Telecommunications or Engineering, Physics or Electrical Engineering (5 posts).

Qualifications: normally 1st or 2nd Class Honours Degree in appropriate subject. (For the Surveying post, professional qualifications in Surveying accepted in lieu.) Teaching experience and research ability desirable for most posts. Some posts require special qualifications or experience in, e.g., solid state Physics, atomic or nuclear Physics, Physics of irradiated materials, Materials and Structures, Fluid Mechanics, Mechanics of Machines, Machine Tools, Production Engineering, Electrical Theory and Measurements, Electrical data transmission, Computing and Automatic Control Devices and Systems, Electric Power and Machines, Electronic Engineering and Instrumentation, Radar and Guided Weapons, Telecommunications, General Instrumentation, including optical and infra-red techniques, servo-mechanisms, theory and practice analogue and digital computing methods.

Salary scales: Lecturer, £615–£1120, or Senior Lecturer, £1166–£1420. Starting pay may be above minimum in both cases. Appointment on the higher scale will not normally be made below age 26. Secondment from, and transfer to, the Scientific Civil Service possible. Prospects of pensionable employment and of promotion. Existing superannuation rights preserved where possible. House available, after a waiting period for married men, and quarters for single men. Candidates should be available to take up duty on or about September 1st, 1959.

Write, Civil Service Commission, 17, North Audley Street, London, W.1, for application form, quoting S4947/59/12. Closing date 31st March, 1959. E5039

ROYAL MILITARY COLLEGE OF SCIENCE, SHRIVENHAM, BERKS

ASSOCIATE PROFESSORS

Four new pensionable posts in residential College for men of high standing in their subjects in the following branches: Ballistics (Department of Mathematics and Physics); Applied Chemistry (Department of Chemistry and Metallurgy); Mechanics (Department of Civil and Mechanical Engineering); Radar and Telecommunications (Department of Electrical and Instrument Technology). The successful candidates will be heads of their respective branches and should preferably be experienced teachers. They will be expected to undertake and lead research in their own fields and to teach to Degree and post-graduate level. Good facilities for instruction and research are available. Salary: £2100 (or over) to £2350. Existing superannuation rights preserved where possible. Secondment from, or transfer to, Scientific Civil Service possible. Rented house available (after a waiting period) for married men, and quarters for single men.

Write, Civil Service Commission, 17, North Audley Street, London, W.1, for application form, quoting S4949/59/12. Closing date 31st March, 1959. E5040

MIDDLESEX COUNTY COUNCIL

SOUTHALL TECHNICAL COLLEGE

GENERAL MAINTENANCE ENGINEER

GENERAL MAINTENANCE ENGINEER initially at Southall Technical College, Beaconsfield Road, Southall, Middx. Salary £605–£755 (if over 26); 44-hour week. Should have sound knowledge of operation of central heating and domestic hot water services, gas and extract ventilation installations, and be able to undertake day-to-day maintenance of this type of apparatus and general engineering equipment usually found in technical colleges. Working knowledge of electrical installations and apparatus and all automatic stoking equipment advantage. Prescribed conditions. Full particulars and 3 referees to Principal, above address. (Quote Z.174E). E9978

PUBLIC APPOINTMENTS

BRADFORD INSTITUTE OF TECHNOLOGY

Principal: E. G. EDWARDS, Ph.D., B.Sc., F.R.I.C.

DEPARTMENT OF MECHANICAL ENGINEERING

SENIOR LECTURER

Applications are invited for appointment of SENIOR LECTURER in the Department of Mechanical Engineering. Applicants should be Graduates, and Corporate Membership of a professional institution is desirable.

The salary scale for men, in accordance with the Burnham Technical Award, is from £1417 10s. to £1627 10s. per annum.

Previous industrial or research experience at a suitable level may be taken into account in fixing the commencing salary.

Further particulars and forms of application may be obtained from the Registrar, Institute of Technology, Bradford, 7.

W. H. LEATHEM,
E5034 Clerk to the Governors.

WAR OFFICE

R.E.M.E. OFFICERS' SCHOOL, ARBORFIELD, NEAR READING

APPOINTMENTS

War Office require at R.E.M.E. Officers' School, Arborfield, near Reading: HEAD OF MANAGEMENT STUDIES. Salary £2200. Qualifications: Fully qualified engineer with University degree in Mechanical or Electrical Engineering or corporate membership of Institution of Mechanical, Electrical or Production Engineers. Wide experience of administration in industry or of management studies and an aptitude for lecturing are essential. INSTRUCTOR (MANAGEMENT STUDIES). Salary £1760 (approximate). Qualifications: Professional standing with qualifications up to University degree standard. 10 years' experience in Engineering industry with up-to-date knowledge of production, planning and control, and work study.—Full particulars and application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting C 111/9A. Closing date 20 March, 1959. E5022

UNIVERSITY OF BRISTOL

LECTURERS

Applications are invited for two posts as LECTURER (one Grade II and one Grade III) in the Department of Mechanical Engineering, at an initial salary within the range:

Grade III: £700 to £850 per annum
Grade II: £900 to £1650 per annum

according to qualifications and experience, with F.S.S.U. benefits and Family Allowance. Applicants should have good academic qualifications and practical experience.

Further particulars may be obtained from the undersigned to whom applications (including the names of two persons to whom reference may be made) should be sent not later than 16th March, 1959.

H. C. BUTTERFIELD,
E9992 Registrar and Secretary.

UNIVERSITY OF LIVERPOOL

DEPARTMENT OF CIVIL ENGINEERING

LECTURER

Applications are invited for the post of LECTURER in the Department of Civil Engineering. The initial salary will be within the range £900–£1250 per annum, according to age, qualifications and experience.—Applications, stating age, academic qualifications and experience, together with the names of three referees, should be sent as soon as possible to the Registrar, from whom further particulars of the conditions of appointment may be obtained. E9982

PUBLIC APPOINTMENTS

WEST RIDING EDUCATION COMMITTEE

MORLEY GRAMMAR SCHOOL (660)

MASTER IN ENGINEERING

Required for May (or September) MASTER to teach ENGINEERING subjects. Graduate or equivalent qualification. Increments allowed for Industrial experience. Graded Post (allowance £75) with prospects of increase. Candidates prepared in Mechanical Science "O" Level and Geometrical and Engineering Drawing ("A" Level). Developing Department.

Applications to be forwarded to the Headmaster, The Grammar School, Morley. E9954

UNIVERSITY OF CAMBRIDGE

A.E.I. FELLOWSHIPS

Applications are invited for the Associated Electrical Industries Fellowship tenable in the Department of Engineering from 1 October, 1959. Stipend within the range £900–£1400 a year with family allowances and F.S.S.U. benefits. Available for research in any branch of Engineering.—Particulars may be obtained from the Secretary General of the Faculties, The Old Schools, Cambridge, to whom all applications should be sent not later than 31 May, 1959. E5014

LIVERPOOL REGIONAL HOSPITAL BOARD

APPOINTMENTS

Applications invited from suitably qualified persons for the following permanent pensionable appointments on the staff of the Regional Engineer:—

(a) SENIOR ASSISTANT ENGINEER (MECHANICAL)
Salary scale: £1010 by £30 (5) by £35 (1) to £1195.
Applicants should hold Corporate Membership of I.Mech.E. and be fully experienced in the preparation of drawings and specifications and the conducting of site surveys in connection with kitchens, laundries and heating and ventilating schemes.

(b) ASSISTANT ENGINEER (MECHANICAL)
Salary scale: £700 by £25 (3) by £30 (1) by £35 (6) to £1015.
Applicants should be at least G.I.Mech.E., or A.M.I.H. and V.E., and have passed the appropriate Institution examinations, be experienced in the preparation of drawings and specifications and the conducting of site surveys in connection with engineering equipment and heating and ventilating schemes.

(c) DRAUGHTSMAN (MECHANICAL)
Salary scale: £425 (at age 21 and over) by £25 (6) by £30 (2) to £635.
Applicants should have had at least three years' technical experience in a mechanical engineering drawing-office and have had some site or workshop experience.

(d) JUNIOR DRAWING-OFFICE ASSISTANT (MECHANICAL)
Salary scale: £205 (male); £201 (female), at age 16, rising to £440 at age 25 years.
Applicants should have had a good standard of education, and it is desirable that the successful candidate should acquire technical qualifications whilst holding the post.

(e) TRACER (MECHANICAL)
Salary scale: £425 by £25 to £470
Applicants should have had a good standard of education and at least three years' previous experience as a tracer in a mechanical engineering drawing office.

(f) CLERK OF WORKS (ELECTRICAL)
Salary scale: £635 by £20 (2) by £25 (3) to £750.
Applicants should have served a recognised apprenticeship as a craftsman and have had at least three years' experience as a foreman. Should have experience in supervising and inspecting electrical installations on building contracts and have a good knowledge of the I.E.E. Regulations.

All salary scales at present under review.

Applications, stating age, qualifications, experience, present and previous posts and clearly stating the post applied for, with names and addresses of three referees (2 technical), to reach me at 55, Castle Street, Liverpool, 2, by 27th March, 1959.

VINCENT COLLINGE,
E5013 Secretary to the Board.

PUBLIC APPOINTMENTS

RUGBY RURAL DISTRICT COUNCIL

WIBTOFT WATER SUPPLY—CONTRACT NO. 12

WOLSTON AREA SEWERAGE AND SEWAGE PURIFICATION—CONTRACT NO. 13

APPOINTMENT OF RESIDENT ENGINEER

Applications are invited for the above appointment, to supervise the following works:

CONTRACT No. 12

The construction of one 220,000 gallon reinforced concrete reservoir, including valve house, about 8 miles of asbestos cement and spun-iron water mains, 3 inch to 8 inch, and the provision of service connections.

CONTRACT No. 13

The laying of 5½ miles of concrete and salt-glazed ware sewers, 3½ miles of asbestos cement pumping mains, three pumping stations and the construction of sewage purification works for 7000 people.

It is expected that Contract No. 12 will commence a few months before Contract No. 13 and both will be under the direction of the Consulting Engineers, Messrs. J. D. and D. M. Watson, MM.I.C.E., 67, Tufton Street, Westminster, London, S.W.1.

The salary is £1200 per annum and the appointment, subject to satisfactory service, will last approximately 2 years and will be terminable by 2 months' notice on either side.

The period of employment may be extended to cover the supervision of further works of a similar nature within the Rural District, which it is expected will form the subject of subsequent Contracts.

A car mileage allowance will be paid.

Applicants, who should be Associate Members of the Institution of Civil Engineers or have comparable qualifications and must have had experience of similar work, should apply in writing to the undersigned not later than 23rd March, 1959, giving full particulars of age, qualifications and experience, and the names and addresses of two persons to whom reference may be made.

Canvassing will disqualify.

H. A. WILDE,
Clerk of the Council.

Council Offices,
24, Warwick Street,
Rugby.
20th February, 1959. E5026

MINISTRY OF TRANSPORT AND CIVIL AVIATION

LONDON

SENIOR INSPECTORS OF ACCIDENTS (CIVIL AVIATION)

Two posts in London for men at least 30 on January 1st, 1959. One post established and pensionable, the other unestablished, but may become pensionable later. Qualifications: Airline Transport or Senior Commercial Pilot's licence and considerable flying including at least 1000 hours as pilot in command. Knowledge of aeronautical engineering necessary, normally to standard required for aircraft engineer's licence; lower if specialised knowledge of navigation offered. Salary scale £1720–£1935. Promotion prospects.—Write Civil Service Commission, 17, North Audley Street, London, W.1, for application form quoting S4937/59. Closing date 17th March, 1959. E9984

CIVIL SERVICE COMMISSION

PATENT EXAMINERS AND PATENT OFFICERS

Pensionable posts for men or women for scientific technical and legal work on Patent applications. Age at least 21 and under 28, with extension for regular Forces Service and Overseas Civil Service. Qualifications: normally First or Second Class Honours Degree in Physics, Chemistry, Engineering or Mathematics, or equivalent attainment, or professional qualification, e.g. A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., A.R.I.C. London salary (men), £635–£1410; provision for starting pay above minimum. Promotion prospects.—Write, Civil Service Commission, 17, North Audley Street, London, W.1, for application form, quoting S128/59. E9976

Classified Advts. continued on page 116

PUBLIC APPOINTMENTS

CITY OF BIRMINGHAM EDUCATION COMMITTEE

VACANCIES FOR TEACHING STAFF

Applications are invited for the following posts in Institutions of Further Education, to commence duty on 1st September, 1959. Application forms (separate for each post) and further details may be obtained from the Principal of the College concerned (stamped, addressed envelope), and should be returned to him as early as possible. Burnham (Further Education) Salary Scales as follows :—

LECTURER, £1260 by £31 10s. to £1417 10s.

Candidates may be granted additional increments above the minimum and up to the maximum of the above scale in accordance with their industrial, professional or research experience approved by the Authority as being of equivalent standard.

ASSISTANT GRADE "B" (man), £682 10s. by £26 5s. to £1076 5s.; (woman), £609 to £861 (plus equal pay increments).

ASSISTANT GRADE "A" (man), £498 15s. by £26 5s. to £945 ; (woman), £451 10s. to £756 (plus equal pay increments).

Candidates may be granted additional increments above the minimum of the above scale for time spent in industry, commerce, professional work or research. There are also additions to the scales for a Degree or for equivalent professional qualifications.

ERDINGTON TECHNICAL COLLEGE
Edwards Road, Erdington, Birmingham, 24
Principal : G. GREASLEY, A.C.G.I., D.I.C., M.I.E.E., A.M.I.Mech.E.

HEAD OF MECHANICAL ENGINEERING DEPARTMENT (GRADE I). Salary scale : £1312 10s. by £31 10s. to £1470.

HEAD OF ELECTRICAL ENGINEERING DEPARTMENT (GRADE I). Salary scale : £1312 10s. by £31 10s. to £1470.

ASSISTANT, GRADE "A," to teach Pre-Senior, along with some S.1 students, in Science, Drawing and Mathematics. Commence duties on 1st May if possible.

ASSISTANT, GRADE "A," to teach Workshop Technology and Engineering Drawing. Practical experience in the handling of machine tools essential.

GARRETTS GREEN TECHNICAL COLLEGE
Garretts Green Lane, Birmingham, 33
Principal : B. C. WHITEHOUSE, B.Sc., A.R.I.C.

LECTURER IN MECHANICAL ENGINEERING, to teach subjects of City and Guilds Machine Shop Engineering, to Intermediate level, and some subjects of O.N.C. Mechanical Engineering. The successful candidate will be required to correlate and develop the theoretical and practical aspects of machine shop engineering. Candidates should possess qualifications of graduate equivalent and have had wide practical experience. Teaching experience is essential.

TWO ASSISTANTS, GRADE "B," to teach O.N.C. and C.G.L.I. Intermediate subjects in Mechanical Engineering. Candidates should possess suitable qualifications and have had practical experience. Teaching experience is desirable.

ASSISTANT, GRADE "A," to teach mainly Engineering Drawing to at least S.1 O.N.C. level, and some Mathematics and Science at Preliminary level. Industrial experience preferable, but not essential.

ASSISTANT, GRADE "A," to teach subjects of the C.G.L.I. courses in Heating and Ventilating, together with some elementary classes in Calculations, Science and Drawing of other C.G.L.I. Mechanical Engineering Courses. Candidates should preferably hold suitable C.G.L.I. Certificates and have had wide industrial experience in the Heating and Ventilating Industry.

HANDSWORTH TECHNICAL COLLEGE
Golds Hill Road, Birmingham, 21
Principal : H. MARSHALL, B.Sc.Tech., A.M.I.Mech.E., A.M.I.Prod.E.

LECTURER in the Department of Mechanical and Production Engineering, to teach subjects up to Higher National Certificate level in Mechanical Engineering. Applicants should be Graduates, or have equivalent qualifications, and should have had industrial experience in addition to teaching experience.

ASSISTANT, GRADE "B," in the Department of Mechanical and Production Engineering, to teach Engineering and ancillary subjects up to O.N.C. standard. Candidates should hold a Degree or a Higher National Certificate and have had teaching and/or industrial experience. To commence duty 1st April, 1959, if possible.

MATTHEW BOULTON TECHNICAL COLLEGE
Suffolk Street, Birmingham, 1
Principal :
J. C. MARTIN, M.A., A.M.I.E.E., A.M.Brit.I.R.E.

LECTURER for Workshop Technology in Ordinary National Certificate in City and Guilds Mechanical Engineering Courses.

ASSISTANT, GRADE "A," for Workshop Practice classes. Industrial experience essential.

SELLY OAK TECHNICAL COLLEGE
Bristol Road, Birmingham, 29
Principal : C. S. MOORE

ASSISTANT, GRADE "B," to teach subjects up to S.2 level in National Certificate courses in Mechanical Engineering and also subjects up to the Intermediate City and Guilds examination in Machine Shop Engineering.

ASSISTANT, GRADE "A," to teach subjects at Preliminary and First-Year levels in National Certificate courses in Mechanical Engineering, and also subjects at Preliminary, First and Second Years of the City and Guilds courses in Machine Shop Engineering.

E. L. RUSSELL,
Chief Education Officer.

E5016

NATIONAL RESEARCH DEVELOPMENT CORPORATION

GRADUATE MECHANICAL ENGINEER

National Research Development Corporation requires GRADUATE MECHANICAL ENGINEER, aged 28 to 35.

Some industrial experience essential. Starting salary according to age, qualifications and experience. Five-day week. Contributory pension scheme.

Apply : Director of Administration, N.R.D.C., 1, Tilney Street, London, W.1. E5010

GREENWICH AND DEPTFORD HOSPITAL MANAGEMENT COMMITTEE

SUPERINTENDENT ENGINEER

SUPERINTENDENT ENGINEER required for a group of three hospitals and associated premises, to be responsible for the engineering services, mechanical and electrical, and the relevant records. Good practical engineering training, sound knowledge of steam boiler plant operation and wide supervisory experience in hospitals essential. Unless eligible for promotion through Health Service experience, applicants should have passed an examination in engineering technology and hold M.T.C.A. 1st Class Certificate of Competency in Marine Engineering, or M.T.C.A. Certificate of Service as 1st Class Engineer or City and Guilds full Technological Certificate in Plant Engineering (1st Class). Salary scale £890–£1045, plus London Weighting. Whitley Council conditions of service. Superannuation scheme.—Applications, stating age, qualifications and experience, and naming three referees, to Group Secretary, G. & D. H.M.C., St. Alfege's Hospital, S.E.10, by 10th March, 1959. E9989

GOVERNMENT OF JAMAICA

CIVIL AVIATION DEPARTMENT

SENIOR EXECUTIVE ENGINEER

To be responsible for the maintenance of all airport facilities at the Palisadoes and Montego Bay airports, including the direction and supervision of staff, hold a watching brief on new construction work, and advise Government, through the Director of Civil Aviation, on and prepare drawings, specifications and contracts for minor additions and alterations to airport facilities.

Contract appointment for one tour of three years. Salary £1750 p.a. Gratuity 20 per cent of salary for each period of three months' resident service. Free passages. Quarters at moderate rent.

Candidates, not over 50 years of age, must be A.M.I.E.E., with a fair knowledge of mechanical work and at least five years' experience in airfield electrical and mechanical work, including electrical, refrigeration and mechanical services used at airports.

Write Director of Recruitment, Colonial Office, London, S.W.1, stating briefly, age, qualifications and experience quoting BCD.98/3204. E9999

BRITISH RAILWAYS

RESEARCH DEPARTMENT (ENGINEERING DIVISION), DERBY

SCIENTIFIC OFFICER, GRADE 2

Vacancy for SCIENTIFIC OFFICER, GRADE 2, initially for work on rolling stock involving stresses in components, performance of bearings, &c. Candidates should have good degree but previous research experience not essential. Consideration given to candidates about to take their degree, engagement being subject to their subsequent passing at required standard.

Salary : £665 to £985 (commencing salary according to qualifications and/or experience).

Superannuation and certain travel facilities.

Medical examination.

Applications stating age, qualifications, &c., to :
Director of Research,
British Railways Research Department,
British Transport Commission,
222, Marylebone Road,
London, N.W.1. E5002

WOKING DRAINAGE—CONTRACT No. 4

RECONSTRUCTION OF OLD WOKING SEWAGE TREATMENT WORKS

APPOINTMENT OF RESIDENT ENGINEER

Applications invited for above position. Salary £1500 per annum. Applicants should be qualified Civil Engineers with previous site experience, preferably on similar work. Works will involve certain amount of deep excavations, construction of reinforced concrete tanks, pumping stations, filters and pipelines up to 33in. diameter. Anticipated starting date, end of April. Duration of appointment just over two years.

Applications addressed to the Council's Consulting Engineers, Messrs. John Taylor and Sons, Artillery House, Artillery Row, Victoria Street, Westminster, S.W.1, must be received by Monday, 23rd March, 1959. E5020

BRITISH SHIPBUILDING RESEARCH ASSOCIATION

MARINE ENGINEERING SECTION

APPOINTMENT

The British Shipbuilding Research Association has a vacancy in the Marine Engineering Section for a person with a good University Degree in Marine or Mechanical Engineering and with practical training and experience. Research experience and/or service at sea an advantage.

The salary will be within the range of £750–£1600 per annum. The commencing salary will, however, depend upon age and qualifications. The appointment is subject to the Federated Superannuation System for Universities.

Applications, with full particulars, should be addressed to : B.S.R.A., 5, Chesterfield Gardens, Curzon Street, London, W.1. E5031

CITY OF BRADFORD

ENGINEERING ASSISTANTS

Applications are invited for the following superannuable appointments in the City Engineer and Surveyor's Department, on the grades indicated.

(a) SENIOR ENGINEERING ASSISTANT, Post 18 : A.P.T. IV (£1025–£1175).
(b) SENIOR ENGINEERING ASSISTANTS, Posts 13 and 119 : Special Grade (£750–£1030).
(c) ENGINEERING ASSISTANTS, Posts 37 and 120 : Grade A.P.T. I or Special (£575–£725 or £750–£1030, according to qualifications).
(d) JUNIOR ENGINEERING ASSISTANTS, Posts 63, 65, 174 : Grade A.P.T. I (£575–£725).

Applicants for Post (a) should preferably hold an Engineering Degree, be A.M.I.C.E./A.M.I.Mun.E., and have had special experience in design of reinforced concrete and steel structure for Multi-Storey Flat construction.

Applicants for (b) should preferably hold an Engineering Degree, be A.M.I.C.E./A.M.I.Mun.E., and have had a good general civil engineering training.

Applicants for (c) should have completed their professional training. Salary on Special Grade will be payable to the successful candidates holding an Engineering Degree or is A.M.I.C.E./A.M.I.Mun.E.

Applicants for (d) should have completed their professional training and have had experience in Municipal and/or Civil Engineering.

Applicants should have completed their National Service. No housing accommodation can be provided by the Corporation.

Applications, on form to be obtained from the City Engineer and Surveyor, Town Hall, Bradford, 1, together with three testimonials, must be received by the undersigned by 17th March, 1959.

W. H. LEATHEM,
Town Clerk.

Town Hall,
Bradford, 1. E5015

BRITISH RAILWAYS

RESEARCH DEPARTMENT (ENGINEERING DIVISION), DERBY

SCIENTIFIC OFFICER, GRADE 2

Vacancy for SCIENTIFIC OFFICER, GRADE 2, initially to study problems connected with dynamics of trains, shock to goods in transit, &c. Candidates should have good degree. Previous experience of research not essential. Consideration given to candidates about to take their degree, engagement being subject to their subsequent passing at required standard.

Salary : £665 to £985 per annum (according to qualifications and/or experience).

Superannuation and certain travel facilities.

Medical examination.

Applications, stating age, experience, &c., to :
Director of Research,
British Railways Research Department,
British Transport Commission,
222, Marylebone Road,
London, N.W.1. E5001

CIVIL SERVICE COMMISSION

SENIOR SCIENTIFIC OFFICERS (a) SCIENTIFIC OFFICERS (b)

Pensionable posts for men or women in all major scientific fields, including physics, chemistry, biology, meteorology and mathematics. Age limits : (a) at least 26 and under 31, (b) at least 21 and under 28. Extension for regular Forces Service and Overseas Civil Service. Qualifications : normally First or Second Class Honours Degree in Science, Mathematics or Engineering, or equivalent attainment ; additionally for (a), at least 3 years' relevant (e.g. post-Graduate) experience. London salaries (men) : (a) £1190–£1410, (b) £635–£1110 ; provision for starting pay above minimum. Promotion prospects. —Write, Civil Service Commission, 17, North Audley Street, London, W.1, for application form, quoting (a) S53/59, (b) S52/59. E9975

AUTOMATIC FIRING EQUIPMENT

Applications are invited for posts as RESEARCH SCIENTISTS for work of national importance on the development of fully automatic firing equipment. The appointment offers opportunities for gaining valuable experience in modern research techniques, automation and instrumentation in well-equipped laboratories at a well-known Research Station in pleasant surroundings. There are opportunities for publishing the results of successful work. Candidates should have a degree (or equivalent) in Physics or Fuel Technology, and previous research experience would be an advantage. Starting salary in the range £750–£1100, and good prospects of advancement for graduates with research ability. 5-day week and congenial working conditions. Superannuation and Grading Schemes.—Apply in writing to Assistant Secretary, Ref. F.4, B.C.U.R.A., Randalls Road, Leatherhead, Surrey.

E9931

WELDING METALLURGIST

required for the

CENTRAL TECHNICAL SERVICE

which advises on the design and procedures for welded joints in heavy and light sections for a wide range of engineering materials ; brazing and soldering and methods of inspection, including interpretation of radiographs.

A recognised engineering apprenticeship and corporate membership of a senior engineering institution or possession of an honours degree in metallurgy, or equivalent are essential. Specialised knowledge of one or more branches of the work outlined and the ability to maintain good liaison with design offices, laboratories, and industrial contractors are required.

Salary between
£845 (at age 25) and £1800
according to qualifications and experience.
Contributory Superannuation. Staff housing scheme.

Send postcard for application form, quoting reference 2954/J1 to Recruitment Officer,

UNITED KINGDOM
ATOMIC ENERGY AUTHORITY,
Industrial Group Headquarters,
Risley, Warrington, Lancashire.

CLOSING DATE : 9TH MARCH, 1959

E9936

OXFORD REGIONAL HOSPITAL BOARD

REGIONAL ARCHITECT'S DEPARTMENT

HEATING ENGINEER

Interesting and responsible work on the design and installation of Engineering Services for new hospitals and alterations to existing ones.

Applicants should be A.M.I.Mech.E. Previous hospital experience desirable but not essential.

Salary £1010–£1195 p.a. Compulsory Superannuation.

Applications by 14th March, 1959, with the names of two referees to The Secretary, Oxford Regional Hospital Board, 43, Banbury Road, Oxford.

Further particulars available from the Regional Architect on request.

E5018

REACTOR ENGINEERS

required by the U.K.A.E.A. at Aldermaston, for the commissioning of a 5MW Light Water Moderated Reactor, its subsequent operation and future modification ; the operation of existing equipment and planning experimental work. Shift work will be involved when the reactors are working continuously.

Previous experience of this type of work would be useful, but it may be possible to provide training for those who have not worked on reactors before. The main requirements are a good engineering experience, managerial ability and Corporate Membership of a Senior Engineering Institution.

An Engineering Degree would be an advantage.

The posts are graded at three levels :

Eng. I —£1855 to £2155.
Eng. II —£1345 to £1800.
Eng. III—£845 (at age 25) to £1150 (at age 34 or over) to £1315.

Contributory Superannuation Scheme. A house or, alternatively, substantial assistance with house purchase will become available for married officers living beyond daily travelling distance.

POSTCARDS for application forms to the Senior Recruitment Officer at A.W.R.E., Aldermaston, Berks. Please quote ref. 2178/25.

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY GENERATING BOARD

AN ENGINEER

is required in the Operations Branch of the Research and Development Department at Headquarters to organise and guide mechanical engineering aspects of research and development. The duties will be concerned with operating problems in conventional power stations. The successful candidate will be required to define the limiting factors in such problems, to give technical advice, prepare relevant programmes of research, and maintain liaison between the generation side of the industry and research laboratories. A creative and practical outlook, and experience in industrial research, preferably related to power station operations, is desirable. Applicants should possess a University Degree in Engineering and/or Corporate Membership of the Institution of Mechanical Engineers. Salary on a scale within the range £2160–£2960 p.a., according to duties and responsibilities.—Applications, stating age, qualifications, experience, present position and salary, should be forwarded to Personnel Officer, 24–30, Holborn, London, E.C.1, by 10th March. Envelopes and applications to be marked "Confidential Ref. ENR/57."

E5000

TENDERS

MINISTRY OF TRANSPORT AND CIVIL AVIATION

LONDON–EDINBURGH–THURSO TRUNK ROAD A.1 WORKS IN THE VICINITY OF STAMFORD, LINCOLNSHIRE

TENDERS are invited for the RECONSTRUCTION and WIDENING of the existing road to provide DUAL CARRIAGEWAYS, 24ft. wide, on improved alignments between Wansford River Nene Bridge and Carpenter's Lodge (about 1 mile south of Stamford), a distance of approximately 4 miles, and the construction of a new by-pass with dual carriageways, 24ft. wide, on the west side of Stamford between Carpenter's Lodge and the existing road to the north-west of the village of Great Casterton, a length of approximately 4½ miles.

Both sections of the improvement include accommodation works, site clearance, excavation, formation of embankments, surface water drainage, carriageway construction (with alternative specifications), provision of hard shoulders, surfacing and associated works.

On the Stamford by-pass section the works also include the construction of 3 two-level junctions with link roads, &c., 2 roundabouts, 9 reinforced concrete bridges (including 5 over roads and 1 over the railway), 2 flood arches, 3 cattle creeps and a short diversion of the River Welland.

Tenderers may be required to furnish evidence of their experience of road and bridge works of this nature.

Contract documents may be obtained from the Consulting Engineers, Messrs. Stirling, Maynard and Partners, 8, Station Chambers, Peterborough, on payment of a deposit of £50 by cheque made payable to the Ministry of Transport and Civil Aviation which will be returned on receipt of a bona fide tender which is not subsequently withdrawn.

The complete set of plans may be inspected at the office of the Consulting Engineers, and at the office of the Divisional Road Engineer, Block 6, Government Buildings, Chalfont Drive, Nottingham, during normal working hours.

Tenders should be sent in a registered envelope addressed to the Assistant Secretary, Highways Management and Services Division, Ministry of Transport and Civil Aviation, 21/37, Hereford Road, London, W.2, to arrive not later than 4 p.m. on Thursday, 23rd April, 1959.

The Minister does not bind himself to accept the lowest or any tender.

A. H. M. IRWIN,
An Assistant Secretary

E5023

CLACTON URBAN DISTRICT COUNCIL

DIESEL ALTERNATOR

TENDERS invited for supply, erection and putting into service of DIESEL ALTERNATOR at Great Bentley Pumping Station, Essex.

Form of Tenders, &c., obtainable from Water Engineer and Manager, Town Hall, Clacton-on-Sea.

Tender Forms must be delivered in plain sealed envelopes endorsed "Tender for Diesel Alternator," but bearing no name or distinguishing mark indicating the sender, to the undersigned by March 28, 1959.

The Council do not bind themselves to accept the lowest or any Tender and canvassing, either directly or indirectly, will disqualify.

CHARLES B. HEARN,
Clerk of the Council.

Town Hall,
Clacton-on-Sea. E5003

INDIA STORE DEPARTMENT

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the supply of:

CEMENTED TUNGSTEN CARBIDE TOOLS AND TIPS, various shapes and sizes.

Please quote reference No. 17565/BMB/HAL.

The Tender forms with schedules and Specifications, which are returnable on Thursday, 26th March, 1959, may be obtained from the above office (C.D.N. Branch) on payment of a fee (which is not refundable) of ten shillings for each tender.—Applications for Tenders should clearly state the reference number of the Tenders required. E9988

TENDERS

GOVERNMENT OF HONG KONG

LAN TAO SCHEME

SHEK PIK DAM

The Government of Hong Kong invite TENDERS from Contractors with suitable experience for the CONSTRUCTION of the SHEK PIK DAM.

The main items of the work are:

(a) a dam about 2800ft. long and 176ft. maximum height, constructed of about 5,000,000 cubic yards of rolled fill.

(b) a concrete overflow bellmouth spillway.

(c) a 17ft. diameter diversion tunnel about 1700ft. long.

Contract documents can be inspected at the offices of the undersigned and can be obtained from them on the payment of Twenty-five pounds, on or after the 27th February, 1959—the deposit to be refunded on receipt of a bona fide tender.

BINNIE, DEACON & GOURLEY,
MM.I.C.E.,

Artillery House,
Artillery Row, Westminster,
London, S.W.1. E9963

USK RIVER BOARD

TIDAL SLUICE DOORS

The Board invite TENDERS for FOUR TIDAL FLAP GATES and THREE EMERGENCY SLUICE DOORS to be erected at Peterstone near Newport, Mon. Specifications and Forms of Tender may be obtained from the undersigned. Tenders in a plain sealed envelope endorsed "Tender, Sluices," are to be received by the Clerk to the Board, "The Croft," Caerleon, Mon., not later than the 31st March, 1959. The Board do not bind themselves to accept the lowest or any Tender.

G. McLEOD, M.I.C.E.,
"The Croft,"
E5024 Caerleon, Mon.

EDUCATIONAL

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

BURSARIES AVAILABLE FOR POST-GRADUATE COURSES in Chemical, Civil, Electrical and Mechanical Engineering for Session 1959–60. Value £500–£700 per annum. Applicants, who should be United Kingdom residents, must have spent at least one year away from University since graduation, preferably in industry.—Further information and application forms from Registrar, Imperial College, London, S.W.7. Closing date May 18th, 1959. E9980 E

UNIVERSITY OF SHEFFIELD

Applications are invited for the John Thompson and the Tube Investments Research Scholarships, tenable for research in Mechanical Engineering and open to graduates of Sheffield or any other approved University: value £400–£500 p.a. plus fees. Closing date 20th June.—Application forms and particulars from: The Registrar. E5027 E

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent successes. 148-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

AUTOMATION.—AUTHORITATIVE COURSES are now available in Digital and Analogue Computer Technology, Applied Electronics, Data Processing and Instrumentation up to professional level by home study. Individual enrolment or industrial group scheme enrolments accepted. Syllabuses and prospectus sent on request.—Write (Dept. S.E.8), E.M.I. Institute School of Electronics, College House, Kensington, London, W.8. E145 E

EDUCATIONAL

COLLEGE OF AERONAUTICS

ONE YEAR POST-GRADUATE COURSE IN THE PHYSICS AND MECHANICS OF STRUCTURAL MATERIALS 1959–1960

Applications are invited for the one-year course which begins on 5th October, 1959. Prospective students must be of graduate status in an appropriate branch of science or engineering and must have practical experience in one of the fields covered by the course.

The purpose of the course is to give instruction in the analytical methods of the theories of elasticity and plasticity and in the basic theories of the nature of materials derived from the sciences of physics, chemistry and metallurgy.

Further information and forms of application may be obtained from: The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks. E5021 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

AN ELECTRICAL ENGINEER is required to undertake responsibility for electrical maintenance and installation and development work in a modern, highly mechanised factory producing seamless steel tubing. The electrical equipment of this plant covers a wide range of A.C. and D.C. drives, up to a capacity of 2000 h.p. The successful applicant would be expected to assume supervisory control of existing electrical staff. Candidates, preferably in the age range 26–30, should hold at least a Higher National Certificate and have had appropriate experience in a similar capacity.—Applications, giving full details of education, previous positions held, in chronological order and salary required, should be addressed to the Works Director, TUBES, LIMITED, Desford Lane, Kirby Muxloe, Leics. E9955 A

APPLICATIONS ARE INVITED FOR THE NEW POST OF PRODUCTION ENGINEER at H. Massil and Sons (Woodturners), Ltd., Welham Green, Hatfield, Herts. The successful candidate will be directly responsible to the Managing Director for all Engineering functions of the Company. As such he will supervise the Works Engineer but will devote most of his time to the development of improved production and handling methods. Applicants should be corporate members of the I.Mech.E., or the I.Prod.E., with past experience in Methods Development work. Knowledge of woodworking will be an advantage but is not essential. Prospects of senior status for a man who proves himself in this new appointment.—Apply in confidence to the Managing Director at the above address. E2315 A

ASSISTANT WORKS MANAGER for Merseyside medium heavy Engineers employing 300. Applicants must have proved organising ability in a similar position and had sound production engineering and production control experience; corporate membership of a professional institution and technical qualifications. Age between 32 and 45.—Please send tabulated chronological details of training and subsequent experience, age and salary required, to Managing Director.—BOX No. E2316, "The Engineer." A

CANADIAN COMPANY REPRESENTING A GROUP OF BRITISH ENGINEERING MANUFACTURERS seek a SALES ESTIMATOR AND CORRESPONDENT for their Montreal office. Preference is for a single man, 26 to 30 age group, who has H.N.C. standard or equivalent, has served a recognised apprenticeship in mechanical or electrical engineering and who has some experience in handling overseas correspondence of a manufacturing firm. Opportunity will be given to study the various products at the United Kingdom manufacturers' work before leaving for Canada.—BOX No. E2308, "The Engineer." A

CHIEF INSPECTOR required for precision engineering Company. Applicants must have sound practical engineering and inspection experience, preferably to A.I.D., A.R.B. and D.I. Arm. requirements. Only men with initiative and previous experience in large organisation need apply.—Write full details of age, experience and education in confidence to Managing Director.—BOX No. E5038, "The Engineer." A

COMPETENT MECHANICAL ENGINEER, with M.O.T. Certificate, experienced in the examination, testing and implementing of all statutory requirements in connection with pressure vessels and lifting equipment, required in Cornwall. Age 35 to 45. Staff appointment with contributory pension scheme. Own car essential.—Apply in writing, giving full details and enclosing copies of any recent testimonials, to Chief Engineer, English Clays Lovering Pochin and Co., Ltd., St. Austell, Cornwall, marked "Confidential." E9986 A

CRUSHING MACHINE DESIGNER

Old-established and well-known firm in the Crushing Plant industry invites applications for permanent and progressive position as

DESIGN ENGINEER

which will shortly be coming available. This is a well-paid post calling for Specialist Engineer having substantial background connected with the practical design and operation of crushing machines for handling hard and medium ores and minerals. Applicants must have proven successful record over a number of years on this particular class of design work. Staff Pension and other facilities.—Write to BOX No. E5025, "The Engineer." A

DESIGN DRAUGHTSMAN required for mechanical design of nucleonic instruments. Pleasant working conditions. Excellent rates of pay.—Apply: Chief Draughtsman, ISOTOPE DEVELOPMENTS, LTD., Beenham Grange, Aldermaston, Berks. Tel.: Woolhampton 451. E5007 A

DESIGNER-DRAUGHTSMAN, experienced in structures and mechanical handling (required by a progressive firm in the Tyneside area). Commencing salary in the range of £980 per annum, paid overtime and pension scheme in operation.—BOX No. E2311, "The Engineer." A

SITUATIONS VACANT

DESIGN DRAUGHTSMAN

J. S. Fry and Sons, Ltd., require a Design Draughtsman having considerable experience of
REFRIGERATION
AIR CONDITIONING and
allied services.

Candidates should be fully qualified, and the prospects are good for the right man, versed in modern practice.

The firm provides ideal working conditions, contributory pension scheme, 5-day week, canteen and social facilities.

Applicants having Higher National or similar qualifications should apply to STAFF OFFICE (E2), J. S. FRY AND SONS, LTD., SOMERDALE, BRISTOL, stating age, experience, qualifications and positions held.

E9990 A

DESIGNER DRAUGHTSMAN (MECHANICAL) required for Research and Development Team engaged on interesting development work in connection with special structures and diesel- and steam-operated plant. Minimum qualifications H.N.C. Age group 24–30 years. The appointment is permanent and progressive in an expanding organisation. Contributory Pension Scheme and good canteen facilities. Salary in accordance with age, qualifications and experience. The works are situated 15 (fifteen) minutes 'bus journey from the centre of Ipswich.—Applications to Personnel Officer, The British Steel Piling Company, Ltd., Claydon, Suffolk. E5011 A

DRAUGHTSMEN, SENIOR DESIGNERS, with a thorough knowledge of mechanical handling, urgently required near Liverpool. Generous salaries to experienced men. Write in confidence, stating qualifications and experience.—BOX No. E9900, "The Engineer." A

ENGINEER with knowledge of Rubber Machinery, both use and design, preferably under 35, but not essential. Good prospects with expanding firm building Rubber Machinery in the South.—State age, experience, qualifications and salary required. —BOX No. E9942, "The Engineer." A

ENGINEERING SALES.—A TECHNICAL REPRESENTATIVE is required by leading manufacturers of power station and industrial water-tube boilers and associated steam engineering equipment. Age range: 35–50 years. Essential qualifications are an intimate knowledge of subject plus good technical qualifications and experience at the level indicated, also ability to present a convincing case for a first-class product.—Applications, with full details of previous experience and an indication of the salary required, should be addressed.—BOX No. E9876, "The Engineer." A

ENGINEER SURVEYORS required for inspection of Cranes and other Lifting Plant. Must have drawing office experience of design of Cranes, also National Certificate for Mechanical Engineering. South London, North Kent and Surrey areas. Salary £735 to £1060 (ESA Scale). Non-Contributory Pension.—Apply Eng. Dept., GENERAL ACCIDENT CORPORATION, LTD., 99, Aldwych, W.C.2. E5035 A

ESSO PETROLEUM COMPANY, LIMITED, have a vacancy at their Fawley refinery for a WELDING ENGINEER. A Degree in Metallurgy is desirable and applicants should have experience of welding large size pipe and pressure vessels. Experience is also necessary in the welding of alloy steel and non-ferrous metals and applicants should be capable of X-ray interpretations. There is an excellent pension scheme and recreational facilities of all kinds are available in a pleasant, rural area borderng on Southampton Water.—Applications, which will be considered in strict confidence, should be addressed to the Employee Relations Superintendent, Esso Refinery, Fawley, Southampton. E9995 A

FULLY QUALIFIED ENGINEER, to be directly responsible to the Partners, required by medium-sized firm of Consulting Engineers in Westminster. Should have had varied civil and structural engineering experience including road and bridge works. Age 35–45.—BOX No. E2303, "The Engineer." A

FOUNDRY SALES REPRESENTATIVE REQUIRED for London and Home Counties. Applicants must be experienced in the sale of all grades of cast iron. Write, giving full details of experience, age and salary required.—BOX No. E2309, "The Engineer." A

GRADUATE with Honours in Physics or Mechanical Engineering required for vacancy in Research and Development team concerned with instrumentation in modern well-equipped laboratory. The post calls for ability rather than experience. An attractive career can be offered to a man, preferably under 30, who wants to progress to a really important post. Good starting salary. Write, giving full details of education and experience.—BOX No. E2313, "The Engineer." A

MECHANICAL ENGINEER

required for N.C.B.'s Coal Research Establishment, Stoke Orchard, Nr. Cheltenham, Glos, to lead a research group responsible for design, development and installation of mechanical and hydraulic machinery for use in the coal industry. A wide general experience of mechanical engineering, together with a good Honours Degree (or equivalent) in that subject is required. Appointment superannuable; salary according to qualifications and experience within scale £1375–£2150.—Write, with full particulars of age, education, qualifications and experience, to the Personnel Officer (X.1342/2E) at the above address.

E9987 A

MECHANICAL ENGINEER, degree or A.M.I.Mech.E., to be responsible for design and technical sales of power transmission developments, particularly couplings. Competency as a design and development engineer matched with personality and enthusiasm are essential. This is a senior appointment with commensurate salary. Excellent Life Assurance and Pension Scheme in operation. Location: Leicestershire. Write fully about your education and career in strict confidence.—BOX No. E5033, "The Engineer." A

Classified Advts. continued on page 118

SITUATIONS VACANT

HEAD ESTIMATOR required after Easter by established and steadily expanding medium weight weld-fabricating engineers in the Home Counties. Good salary with house to man with right experience. Applicants can only be considered who give in their own handwriting full details of career to date, including exact description of classes of work, present employer, and salary.—BOX No. E2307, "The Engineer." A

MANAGER

West Riding Engineering Company requires MANAGER for its Flexible Shaft Coupling Department. Applications are invited from Degree or Chartered Mechanical Engineers, preferably not above 45 years of age, with sound design and sales experience. Salary range £1500–£1750.—Write, giving full details, to Managing Director, BOX No. E2314, "The Engineer." A

MECHANICAL HANDLING

CONTRACTS ENGINEER and SITE ENGINEER required by important manufacturer of mechanical handling equipment in the Midlands. Previous experience in the general design, handling and installation of large coal and ore handling plants essential. Minimum qualification H.N.C. or equivalent.—Applications, giving details of age, salary, experience and qualifications, should be sent to BOX No. E9997, "The Engineer." A

RAILWAY ENGINEER. A.B.C. COUPLER & ENGINEERING CO., LTD., require an ENGINEER with general railway experience to take control of design and development on technical side of components of rolling stock, &c.—Write particulars of training and experience, approximate salary required, to The Secretary (Confidential), Fallings Park, Wolverhampton. E5029 A

SALES ENGINEERS

A Scottish heavy machine tool engineering company of medium size requires Two Sales Engineers, one for the Birmingham and South of England area and the other for Northern England.

Candidates should have Higher National Certificate in Mechanical Engineering, or equivalent, and should have works training in addition to drawing-office experience. Sales experience is desirable, but not essential. Preference for men aged under forty.

Successful candidates would operate from their homes in the first instance after initial training with the company. Salary in the region of £1100 p.a., with car provided.—Write BOX No. E9973, "The Engineer." A

SENIOR DESIGN-DRAUGHTSMAN required, able to take full responsibility for the design and detailing of large mechanical handling contracts for coal handling, ore handling, and similar plant. Minimum qualification H.N.C. or equivalent. Previous experience in this class of work essential. Superannuation and life assurance scheme in operation.—Applications, giving details of salary, training and experience, &c., to NEW CONVEYOR CO., LTD., Brook Street, Smethwick, Birmingham, 40. E9996 A

SENIOR INSTRUMENT ENGINEER

Leading Contractors to the Oil Refinery and Chemical Engineering industry would be pleased to receive applications from suitably qualified engineers who have a sound experience in the design of large scale control installations. This position offers excellent prospects and a commencing salary of at least £2500 p.a.

Please write full particulars which will be treated in the strictest confidence to Managing Director, BOX No. E9946, "The Engineer." A

TECHNICAL SALES REPRESENTATIVE wanted to take over our West Lancashire, Cheshire and Potteries territory in which we are well established. This is a full-time appointment and a good knowledge of gearing is essential.—Applicants should write giving list of qualifications, past experience and salary required, to be treated in confidence.—BARLOW AND CHIDLAW, LTD., SALFORD 6, LANCS. E5032 A

THREE YOUNG TECHNICIANS with experience of modern building and structural techniques are required by a fast expanding organisation to help with the development and marketing of a range of new structural products for the building industry.

Initial training in the drawing-office on design and estimating work with the opportunity as the business grows to specialise in a particular branch, e.g. design, sales, administration, development work.

Preference will be given to holders of O.N.C. or H.N.C. (Building or Civil Engineering) with at least two years' practical drawing-office experience in modern steel, concrete or timber construction.

A starting salary of £450–£800 will be paid according to experience.—Write for application form to Box TY7, A.K. Advertising, 212a, Shaftesbury Avenue, London, W.C.2. E5008 A

TRANSLATORS required. Must be British by birth and education, able to write fluent English, accustomed to handling highly technical German texts; journalistic experience desirable.—State subjects handled, typing ability and minimum fees.—Brunton Translations, Charlotten-Str. 47, Dusseldorf, Germany. E2290 A

SITUATIONS VACANT

MSL have been retained to advise on the appointment of a

CHIEF ENGINEER

for a public company in London manufacturing specialised electronic and control equipment. He will be responsible to the Managing Director and will manage a department of over 300 engineers, technicians and tradesmen engaged in design and development work.

Candidates aged between 40 and 50 must be graduate engineers, electrical or mechanical, and must have experience of electronic and control equipment including servo mechanisms. They must already be Chief or Deputy Chief Engineers in control of a large design and development department (not less than 100). Initial salary £2,500–£3,000; car will be provided.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1543, to D. M. Sidney.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E134 A

SITUATIONS VACANT

MSL have been retained to advise on the appointment of a

DIRECTOR OF MANUFACTURING

for a light engineering public company making a consumer product by a highly mechanised process, employing 800 at two main factories with headquarters in London.

Appointment to the Board will follow in one to two years, subject to satisfactory performance. The main responsibility and interest in the appointment will be the organisationandadministration of high-speed mass-production and its further mechanisation with the prospect of an increasing share in the direction of the company as a whole.

Candidates must have a strong engineering background, preferably with a professional qualification, and experience of responsible positions in works management, preferably in mass-production and light engineering.

Age preferred 40-45. Starting salary would not be less than £3,000, but candidates earning more, with especially valuable experience, would be considered.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1188, to M. B. Berks.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E150 A

SITUATIONS VACANT

MSL have been retained to advise on the appointment of a

SALES MANAGER

for a medium sized specialist engineering company situated 20 miles West of London. He will serve as an assistant sales manager for about a year in order to familiarise himself with the company's products and customers. Thereafter he will be promoted and made responsible for the management of a small force selling semi-processed products to engineering consumers throughout the country.

Candidates between 30 and 40 should preferably be graduates. They must have had some experience of technical selling but stress will be laid on selling ability and executive and commercial competence rather than on technical excellence.

Initial salary including bonus in the range of £1,250–£1,750; a car will be provided.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1542, to D. M. Sidney.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E142 A

MACHINE SHOP FOREMAN

Applications invited from experienced men (age 30–50), to take charge of the modern and well-equipped department of an established light engineering company, West London area.

Applicants should possess good experience of machine tools, and ability to organise and control labour.

A good salary and Pension Scheme is offered.

Please apply, stating age and previous experience, to BOX No. E9974, "The Engineer." A

CORROSION ENGINEER

An opening is available in London Office of International Oil Company for a B.Sc. METALLURGIST or MECHANICAL ENGINEER to study and solve corrosion problems encountered in the producing, refining and marketing of oil and oil products and to provide technical assistance in the development of materials and protection devices.

Candidates, under forty, must have had a minimum of five years of this experience including practical field inspection and materials work, and be willing to visit overseas locations from time to time.

Apply in writing giving full particulars to BOX No. E9927, "The Engineer." A

TECHNICAL ENGINEERING WRITER

is required by a large firm of component manufacturers in the Midlands dealing with the Automobile, Aircraft and general engineering industries.

Must be a qualified engineer with journalistic experience, capable of producing technical descriptions of products and installations from information acquired direct from Drawing and Design Offices.

Age 25–30.

Salary range: £1000–£1400.

Applications, in writing, stating age, experience, qualifications and salary to BOX No. E5036, "The Engineer." A

The Office of Electricity in the Lebanon seeks

EXPERIENCED ENGINEER

able to assume the responsibilities as

CHIEF OF A STEAM GENERATING STATION

Send offers with curriculum vitæ, stating conditions, to P.O.B. 131, BEYROUTH.

E9710 A

ENGLISH ELECTRIC ATOMIC POWER DIVISION

Whetstone, Near Leicester

wish to engage

MECHANICAL DESIGN ENGINEERS

and

PLANT LAYOUT ENGINEERS

to undertake a variety of design work at all stages from the projected layout to the completed design of nuclear power stations. Previous experience in this field is not essential but candidates having a minimum qualification of H.N.C. in Mechanical Engineering should have several years' successful design experience in medium or heavy engineering.

These appointments offer considerable scope for initial design and present an excellent opportunity for advancement.

Please write, giving details of education, qualifications and experience, to Dept. C.P.S., Bush House, 336/7, Strand, W.C.2, quoting reference E1817G.

E1817G A

SITUATIONS VACANT

PRESSED STEEL COMPANY LIMITED

The Company is engaged in large scale manufacture of motor car bodies, commercial, domestic and industrial refrigeration plant and railway rolling stock, and employs some 18,000 people in plants at Oxford, Swindon, Reading and Paisley. It invites applications for the following appointments :—

PLASTICS TECHNOLOGIST

Highly qualified Plastics Chemist to strengthen a research and development team working on the application of plastics to the Company's products. Degree in Chemistry and experience in the research and development department of large industrial chemical company essential ; special knowledge of polyesters, polystyrenes, epoxy resins and their applications desirable. Associate Membership of Institute of Plastics an advantage. Age range up to 35 years. Location Oxford.

STRESS ENGINEER

Qualified Stress Engineer, to lead team of stressmen engaged in stress problems associated with the design and manufacture of rolling stock in light alloys. Candidates must be able to demonstrate success in solving problems of stress, strain and fatigue in large welded and riveted structures, preferably in both non-ferrous alloys and ferrous metals. Preferred age range 35/40. Location Paisley.

These openings offer opportunity to join an expanding organisation in research and development of new techniques of manufacture. Conditions of employment accord with best industrial practice. Applications, with full details of education, training, experience and salaries earned, may be made to the Personnel Director at Cowley, Oxford.

E5041 A

SITUATIONS VACANT

CIVIL ENGINEERS

based on London but prepared to go on short visits overseas are required in the

DESIGN DEPARTMENT

for work of an advanced nature on bridges, dams, jetties, &c. These are senior positions calling for good design experience, backed by a degree and a background of construction with contractors, and in the

PROJECT DEPARTMENT

for pre-planning of similar work, calling for good construction experience and some knowledge of design. Minimum qualifications are exemption from Parts A and B of the Institution of Civil Engineers.

These positions give excellent opportunities to gain varied and interesting experience, and should appeal to engineers 28–35 years of age. Please write with salient information to :

The Head of the Design Department,
THE CEMENTATION COMPANY LIMITED
20, Albert Embankment, S.E.11.

E9929 A

SITUATIONS VACANT

W. H. ALLEN, SONS & COMPANY, LTD.,
BEDFORD

require for their Production Engineering Department

WORK STUDY ENGINEERS

experienced in the application of Work Study to machine or assembly shops.

DRAUGHTSMEN

for the design of Jigs, Tools, Fixtures and Tool Layouts.
These positions will interest men of sound education and practical experience, who can carry out on their own initiative, studies and investigations into problems affecting the small-batch production of Electrical Machinery, Diesel Engines, Steam and Gas Turbines and Centrifugal Pumps.
Please apply in writing, stating age, present salary and full details of education, training and experience to

THE PERSONNEL MANAGER

E9943 A

SITUATIONS VACANT

C. A. NORGREN LTD.
and Associate Companies

have a position with excellent prospects open for a

QUALIFIED ENGINEER

Compressed Air Equipment is our business and our Company is a progressive one in a growing field.

We offer a salary according to qualifications for duties involving Experimental and Drawing-Office work, Customer Liaison and acting as Assistant to General Manager, Technical Manager and Product Engineer.

If you are aged 26–32 years, have an Engineering Degree and Workshop training, and consider you have a pleasing personality and executive ability, we should like to hear from you.

Please write in confidence giving full details of education and career to :

General Manager, C. A. NORGREN LTD.
SHIPSTON-ON-STOUR, WARWICKSHIRE.

E9934 A

BUDENBERG GAUGE CO. LTD.,
require
A MECHANICAL ENGINEER AS ASSISTANT TO CHIEF ENGINEER

The candidate should be aged 25 to 35, have an honours degree in engineering, have served an apprenticeship and have had several years of experience in industry.

The work is extremely varied and interesting. Main duties are (1) technical applications of instruments, especially pressure gauges and thermometers, in wide fields of industry ; (2) preparing of technical specifications for embodying in tenders ; (3) designing or assisting in the design, of small mechanisms ; (4) visiting customers and users to observe instruments in use ; (5) assisting the Chief Engineer and deputising for him in his absence.

Commencing salary will depend on age, qualifications and experience. There is a favourable compulsory pension scheme. Removal assistance would be considered for a suitable candidate.

Apply in writing only, giving age, full particulars of education and experience to :

Managing Director,
Ref. C.F.B.,
Box No. 5,
Altrincham,
Cheshire.

E9983 A

THE NUCLEAR POWER PLANT COMPANY LIMITED
requires a
CHIEF CONSTRUCTIONAL ENGINEER

This is a new and senior appointment which gives opportunities for further promotion.

The successful candidate will be responsible for the planning and construction of the Company's nuclear power stations in the United Kingdom and abroad.

Applicants should have considerable experience in both the planning and erection of power stations and some design experience would be preferable.

The appointment is pensionable and the Company is prepared to take into account any accrued pension rights of the successful applicant when making the appointment.

Suitably qualified engineers are invited to write, giving full details of experience and qualifications to the

General Manager,
The Nuclear Power Plant Co., Ltd.,
Booths Hall,
Knutsford,
Cheshire.

All applications will be treated in confidence and should be marked PRIVATE AND CONFIDENTIAL, quoting reference TE/CE/65.

E5037 A

ENGLISH ELECTRIC
ATOMIC POWER DIVISION
Whetstone, Near Leicester

A number of vacancies have arisen for

MECHANICAL ENGINEERS
and
CHEMICAL ENGINEERS

to work on problems associated with heat transfer and fluid flow.

These appointments exist in the teams dealing with the initial layout and design of nuclear power stations and successful candidates will find they have every chance to undertake original design work in a progressive department.

Applicants should hold a degree or its equivalent in mechanical or chemical engineering and some experience of the design or development of turbo machinery would be an advantage.

Please write, giving details of qualifications and experience, to Dept. C.P.S., Marconi House, 336/7, Strand, W.C.2, quoting reference E1814N.

E9994 A

BLACKBURN (DUMBARTON) LIMITED

are expanding their Engineering Division and there are vacancies in the Design Office, Development and Prototype Manufacturing Departments for the following.

1. DESIGN DRAUGHTSMEN up to the age of 35, with a Higher National Certificate or equivalent, in Mechanical and/or Electrical Engineering, to fill Senior and Junior positions.
2. DEVELOPMENT ENGINEERS up to the age of 35, who possess a University degree or at least Higher National Certificate or equivalent, in Mechanical and/or Electrical Engineering.
3. A SUPERINTENDENT to organise and take charge of the Experimental and Prototype Manufacture. Good practical experience is required in Light Electrical and Mechanical Engineering. The applicant should possess a Higher National Certificate or equivalent, as well as a sound background of fundamental engineering principles and processes.

The above posts are key positions in an expanding organisation and will promote opportunities for those people with drive, initiative and ideas, and who are not afraid of hard work.

It may be possible to provide housing facilities or assistance towards housing to suitable applicants.

Contributory Pension and Free Life Assurance Schemes in operation.

Applications, giving full particulars of experience and technical qualifications, should be made in writing not later than Monday, 16th March, 1959, to the PERSONNEL MANAGER, BLACKBURN (DUMBARTON) LIMITED, CASTLE ROAD, DUMBARTON.

E5012 A

TRAINEE ENGINEERING BUYER

An opening occurs for a trainee buyer in the Engineering & Standards Section of the CENTRAL PURCHASING DEPARTMENT of the DUNLOP GROUP. This section is located at Fort Dunlop, Birmingham, and is responsible for the purchase of plant, engineering materials and tools for overseas factories, and for the co-ordination of engineering procurement and contracts in connection with Company projects.

The successful applicant will have a three months' course of training in Birmingham and, if satisfactory, will then proceed on an eighteen months' course of instruction at the Group's principal factories. This will include training in matters relating to engineering contracts and procurement, and will be designed to acquaint the trainee with equipment and procedures used by the Company. It will include training with Accounting, Engineering, Insurance, Legal, Shipping and administrative departments.

Applicants should be University Graduate Engineers or equivalent, aged 24–26, inclusive, and should have completed their two years' post-graduate apprenticeship. Those interested are invited to send a letter or postcard asking for a confidential application form, to the

PERSONNEL MANAGER (ES), FORT DUNLOP, ERDINGTON, BIRMINGHAM, 24.

E9985 A

RESEARCH ENGINEER/ PHYSICIST

DIVISION OF METROLOGY, C.S.I.R.O., AUSTRALIA

Applications are invited from Honours Graduates in Engineering or Science, with Physics as major subject and post-graduate experience. Must be capable of initiating and developing new and improved measuring techniques and equipment in engineering metrology, particularly large-scale metrology, dynamic metrology and gears and cutting equipment. Salary dependent on qualifications and experience in the ranges : £A1326–£A1951 p.a. or £A2061–£A2336 p.a. Further particulars of conditions, fares, &c., obtainable from :

Mr. E. J. Drake,
Chief Scientific Liaison Officer,
Africa House,
Kingsway, London, W.C.2.

to whom applications, referring to Appointment No. 750/188, should be addressed by the 28th March, 1959.

E5017 A

SITUATIONS WANTED

COST CONTROLLER BUDGET OFFICER, qualified, experienced standard costs, budgetary control, management accounts.—Seeks responsible position. Available immediately.—BOX No. E2295, "The Engineer." B

STRUCTURAL ENGINEER—Steelwork, with twenty-five years' experience from Print-boy to Chief Designer, at present Branch Manager for East African territory. Returning June, 1959, seeks managerial or executive position in British Isles.—BOX No. E2312, "The Engineer." B

SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved.—Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E109 MW

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone : Knottingley 2743/4). E116 MW

Classified Advts. continued on page 120

PATENTS

THE PROPRIETOR OF BRITISH PATENT NO. 685,723, entitled "SPRING FORMING MACHINE," offers same for license or otherwise to ensure practical working in Great Britain.—Inquiries to SINGER, STERN AND CARLBERG, 14 E. JACKSON BOULEVARD, CHICAGO 4, ILLINOIS, U.S.A. E9928 H

BUSINESSES and PREMISES

N.E. OF LONDON. 18,500 square feet site area 2·6 acres. Newly erected Industrial Property eminently suitable for Engineering and Allied Trades. Single storey production area with headroom 17ft. 6in. Central heating throughout. Offices, canteen and all main services connected. Extensive concrete yards. Land for expansion. For sale Leasehold.—Apply to Chamberlain and Willows, 23, Moorgate, E.C.2 (MET. 8001). E5004 L

GENERAL SHEET METAL AND LIGHT ENGINEERING BUSINESS. Old-established, North London. Freehold premises. Well equipped Plant and Machinery. For sale as a Going concern. Price £75,000, s.a.v. Further particulars: Henry Butcher and Co., 73, Chancery Lane, London, W.C.2. Tel. No.: HOL 8411. E5028 L

BUSINESS OPPORTUNITIES

SMALL ELECTRO-MOTORS. Dutch export firm, which operates as sales office for manufacturer, wishes to export direct to manufacturers, importers/exporters in the U.K. small electric motors of very high quality at competitive prices. These motors are already exported to many countries, and are used for mixers, grinders and various other purposes. Motors to be used for special purposes or of special design can be offered.—"HACE," P.O. Box 296, Eindhoven, Holland. E5009 O

FOR HIRE

LATTICE STEEL. Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. ('Phone, SLOane 5259). E103 K

AGENCIES

LONDON OFFICE
EXPORT AND SHIPPING ORGANISATION

City firm, small but active, highly efficient, under personal supervision Managing Director and with impressive record Export business, offers first class individual service to limited number of manufacturers as London Office or Export Organisation, handling all aspects selling and/or shipping to overseas markets. We can relieve manufacturers of all details, transportation, packing, shipping, documentation, &c.

BRENDAN BUTLER LIMITED,
3A, Wood Street, London, E.C.2.
Telephone: MONarch 7312 and 2529.
E5030 D

MISCELLANEOUS

TIME RECORDERS, Sales, Rentals, Service. Telephone Hop 2239.—Time Recorder Supply and Maintenance Co., Ltd., 157-159, Borough High Street, London, S.E.1. E110 I

GERMAN TRANSLATIONS of technical and scientific literature, &c., by German B.Sc., expert service. Write.—BOX No. E2317, "The Engineer." I

MACHINERY Etc. WANTED

WANTED, 750/1000kW., 3·3kV., 3-phase, 50 cycles Diesel Alternator Set. Other voltages considered, must be in good operational order. State full details, price and where can be inspected.—BOX No. E9991, "The Engineer." F

FOR SALE

HYDRAULIC PRESSES

3000-ton PLATE FORMING AND BENDING PRESS, table 16ft. by 4ft. 6in., admits 10ft. 6in. between columns.
2000-ton HYDRAULIC FORGING PRESS, admits 8ft. 6in. between columns.
1000-ton HYDRAULIC FORGING PRESS by Wellman, admits 6ft. between columns.
LARGE STOCK OF HYDRAULIC PRESSES OF ALL TYPES.

REED BROTHERS (ENGINEERING), LTD.,
REPLANT WORKS,
WOOLWICH INDUSTRIAL ESTATE,
LONDON, S.E.18.
Telephone: Woolwich 7611/6. E9887 G

FOR SALE

Edwards

BRADLEY & CRAVEN Power Geared Open-Ended Guillotine Shearing Machine, Undercrank type, capacity 84in. by ¼in., gap in open ends 4½in., fitted with automatic sheet hold-down and adjustable gauges, weight approximately 75 cwt.

QUICKWORK No. 321, Motorised Rotary Shearing Machine, with circle cutting attachment, arranged motor drive for 400/440/3/50, capacity mild steel 14 S.W.G., cuts circles from 6in. to 60in. diameter, hand feed control lever enables operator to cut intricate shapes by hand, weight approximately 18 cwt.

B.E.N. Model TS9, 2-Stage Automatic Air Compressor Unit, comprising: 2-stage vee type, air-cooled compressor, driven by vee ropes from 2 h.p. 1440 r.p.m. motor with starter suitable for 400/440/3/50, displacement 9 cu. ft. per minute, working pressure 200 lb. per square inch.

RHODES No. 20 size Inclinable Power Press, fitted with Udal automatic press guards, pressure exerted approximately 20 tons, stroke 2in., centre to back 8in., size of bed 22in. by 40in., hole in bed 10½in. by 10½in., weight approximately 20 cwt.

WESTON Model 400/100, Double-Sided Friction Screw Press of welded steel plate construction, arranged motor drive for 400/3/50, pressure exerted approximately 120 tons, maximum stroke 11in., diameter of screw with four starts 6½in., size of bed 21½in. by 18in., weight approximately 5 tons.

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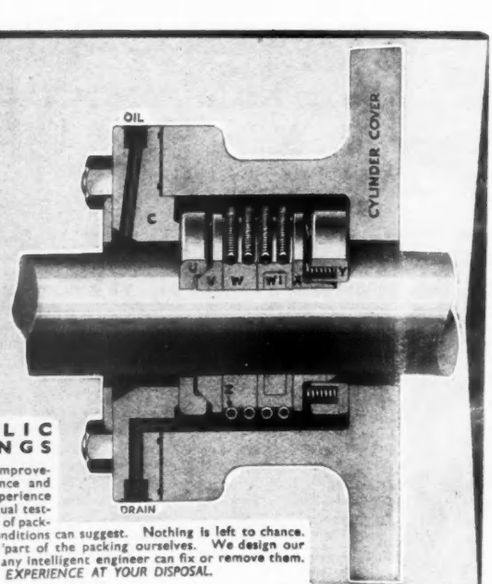

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March 9–10	**Miscellaneous stores,** including	M.O.S. Storage Depot, **Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272.)
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March 12	**Office equipment,** including	Hawker Aircraft Factory, **South Shore, Blackpool.**	**LESLIE A. BUTSON** (Dept. L), 16, Birley Street, Blackpool. (Tel.: 21073.)
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March 17–18	**Machine tools, plant and miscellaneous stores,** etc.	M.O.S. Storage Depot, **Harrogate Road, Yeadon, Leeds.**	**DACRE, SON & HARTLEY** (Dept. L), Station Road, Otley, Yorks. (Tel.: 3321.)
March 20	**Miscellaneous stores,** including clothing, etc.	Command Ordnance Depot, **Coypool, Marsh Mills, Plymouth.** (Sale at Kinterbury House.)	**WOOLLAND, SON & MANICO** (Dept. L), Kinterbury House, St. Andrews Cross, Plymouth. (Tel.: 65356.)
March 25	**Machine tools and miscellaneous stores.**	Technical Stores Depot, **Old Dalby, Leics.** (Sale at Melton Mowbray.)	**SHOULER & SON** (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 3081.)

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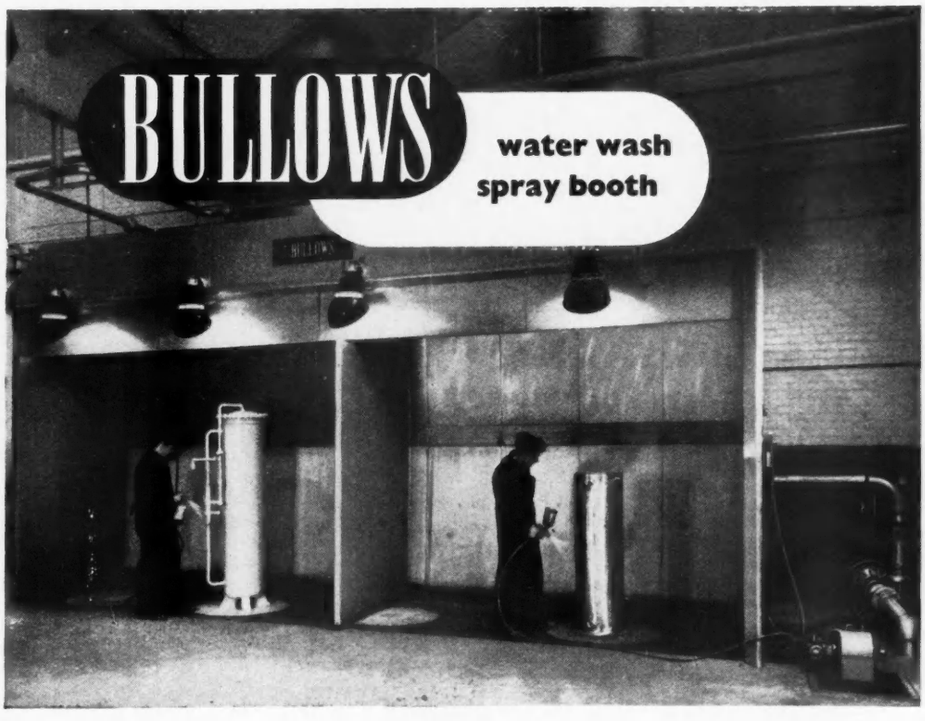

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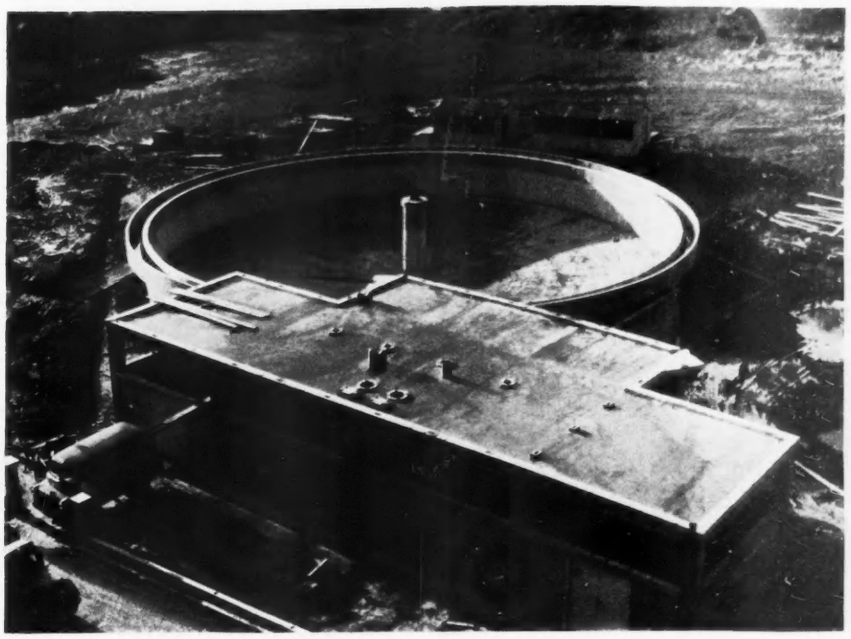

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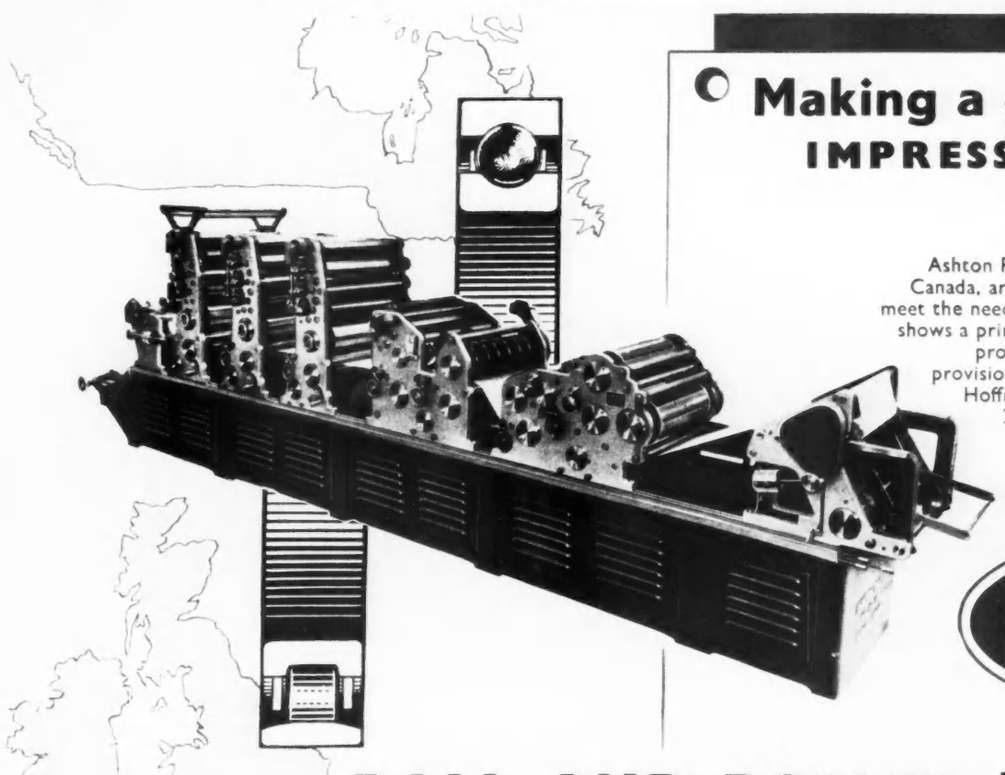

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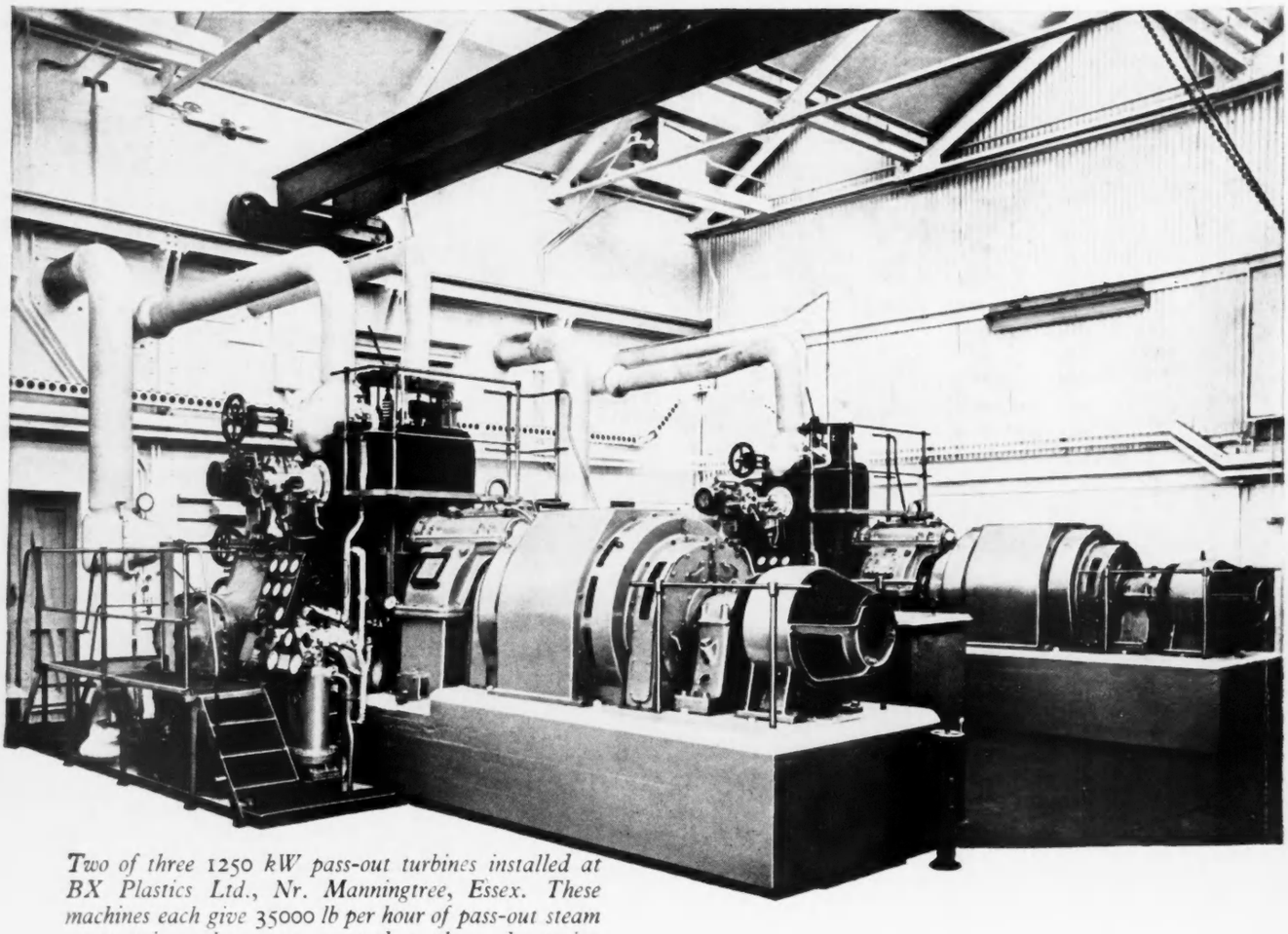

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